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THE FACTORS OF SAFETY IN ANIMAL STRUCTURE AND ANIMAL ECONOMY[1]

THE living animal body is like a machine in action. Like a machine its structures are subject to a variety of stresses, and like a machine the work is accomplished by an expenditure of energy derived from a supply of fuel. I intend to discuss in this lecture, whether, as in the human-made machines, the structures and functions of the animal mechanism are provided with factors of safety. The term 'factor of safety' is employed in engineering to designate the margin of safety required in the building of engines, bridges, houses, etc. For instance, in designing a boiler, if the tensile strength of the steel of which the plates and stay-bolts are made, is 60,000 pounds per square inch, the actual stress which is allowed for the work of the boiler should not be more than 10,000 pounds per square inch for the plate and not more than 6,000 pounds per square inch for the stay-bolts; that means the stress to which the plates or the bolts may be exposed in the boiler should only be one sixth or one tenth of the actual strength of the steel. The factors of safety are said to be here six for the plate and ten for the bolts. In some instances the required factors of safety may be as low as three, in other cases again they may be as high as twenty and even forty. The character of the stress to which the structures might be subjected is an important point in deciding upon the

[1] Harvey Society lecture, delivered at the New York Academy of Medicine, December 15, 1906.

size of the margins of safety. Structures, for instance, which are to be employed for alternating loads require high factors of safety; the highest margin of safety is required when the structures are subjected to rhythmic shocks. In constructing a bridge or a machine it is then calculated that the structures should be capable of withstanding not only the stresses of reasonably expected maximum loads, but also the stresses of six or ten times the size of such loads. The factor of safety has its foundation in our ignorance of what might happen and in the reasonable desire to meet unexpected contingencies. Some writers are therefore inclined to designate the factors of safety as factors of ignorance.

It is obvious that the factors of safety are applicable not only to the structures, but also to the supply and expenditure of energy of the machine. The supply of fuel is calculated to have the engine in readiness not only for expected maximum work, but also to be capable of meeting unexpected contingencies. On the other hand, when there is no exceptional need for it, no engine is allowed to perform maximum work; this economy here is again a factor of safety.

Are the structures and the functions of the living animal body provided with such factors of safety? As far as I know, that question has never yet been clearly raised, and certainly was never made the subject of a direct investigation. There is, however, no lack of casual remarks bearing on that problem and these are manifestly unfavorable to an assumption of the existence or requirement of factors of safety in animal organisms. On the contrary, there are many to whom it is apparently self-evident that nature is economical and wastes neither material nor energy. Theories and practical suggestions are based on such a view as a premise which seems to their authors to require no special proof. Verworn, for instance, asserts that the assumption of special inhibitory nerves for skeletal muscles can be rejected *a priori*, because the presence of such nerves would be a waste of matter and energy and in contradiction with the prevailing principle of economy in the animal body. Another instance is the extreme position held by some recent writers with respect to the supply of energy to the animal machine. Factors of safety, maximum or optimum supply of fuel, do not come in for a consideration in the discussion of these writers. The argument is directed against the use of a dietary standard which represents the average mean supply of energy, the minimum supply of food being considered as the ideal standard of diet. As is known to all of you, Professor Chittenden and his co-laborers have carried out nutrition experiments of long duration upon a number of men. The essential feature of these experiments was the use of a low proteid diet; in some instances the diet was also combined with a considerable reduction in the caloric values of the food. All the subjects of the experiments retained their usual health. Professor Chittenden admits that the diet used in these experiments, especially with regard to the proteid intake, represents the minimum requirement of the human body; he, nevertheless, earnestly advocates its acceptance as a general standard of diet, assuming *a priori* that the minimum food with which a number of men can manage to live for some time without harm is the desirable standard of supply of energy for all animal machines. Whereas in the economy of the human-made mechanisms and, in fact, in the economies of all human organizations, decrease in supplies and increase in expenditure lead invariably to disaster, it would seem that in the physiological economy of the living mechanism

such a procedure may even lead to a greater efficiency of the mechanism. Professor Irving Fisher tells us recently that nine Yale students under the influence of prolonged mastication of a diet greatly reduced in proteid and in caloric values, gained very much in endurance in performing certain physical tests.

Is there, indeed, a difference between the economies of human-made organizations and those of the living organism? I have stated above that the factcrs of safety in mechanical constructions are after all only factors of ignorance. Possibly wise nature constructs her organisms on such an efficient principle which permits the accomplishment of the greatest amount of work on a minimum supply of material and energy. It would be a fascinating distinction between a dead mechanism and a living organism—if true.

The subject of this lecture will be an investigation of this question, an investigation whether the structures and functions of the animal organism are constructed with a special consideration for the greatest economy or for the greatest safety. Or to leave the purposefulness of the organization out of discussion, I may perhaps put it more correctly by saying that it will be essentially an investigation into the ratios of the supply of material in many organs of the body to the amount of work they are expected to perform. I believe that the investigation may lead to some instructive general conclusions of a theoretical and practical character. As already stated, the problem seems to me to be new and, as far as I know, no original investigations were carried out with the special purpose of solving it. There are, however, a great many well-established facts brought out in theoretical and practical work undertaken for other purposes, which are, nevertheless, capable of throwing a good deal of light upon our problem. Such facts have the advantage of being unbiased witnesses, since no preconceived theory was at the bottom of their discovery. My task will consist in reviewing these facts as far as they are available, or more correctly, as far as they are known to me, and bringing them impartially in proper relation to our problem.

I shall commence with the plain tissues of the body. In the multitude of studies on these tissues there are not many investigations which could be utilized for our purpose. However, a series of careful investigations, recently published by Triepel, have an intimate bearing on our problem. Triepel investigated the elasticity and resistance of several tissues, like muscle, tendon, elastic tissue, bone, cartilage, etc. For us the following statements are of special interest. For muscle, tendon and elastic tissue Triepel found that the maximum stretching which may occur in the animal body is not far below that degree which can cause tearing of these tissues. The resistance of bones and cartilages to a crushing stress is, however, far above any stress which might occur in normal life. With regard to muscle, tendon and elastic tissue it appears, therefore, that the structures in themselves have practically no factors of safety above the maximum stress to which they might be subjected. Any unexpected tension above the maximum occurring in ordinary life might lead to a rupture of these tissues. Triepel, however, calls attention to the fact that the degree of stretching of these tissues is greatly limited by their connections with the structures surrounding them, especially by the skeletal parts. These limitations will for the most part prevent these tissues from reaching their breaking point. We may then say that muscle, tendon and elastic tissues have no factors of safety in the

structures themselves; but they are provided, nevertheless, with some such factors by their connections with other tissues. The bones and cartilages, on the other hand, which are but little influenced by other tissues, are provided with a very large margin of safety over the stresses to which they might be exposed normally. Triepel here makes a remark which has a direct bearing upon the problem with which we are dealing. He says that the large surplus of material in bone and cartilage shows that nature does not follow the law of obtaining a result by the smallest possible means.

It is worth noticing that the large margin provided here can not have the object of offering protection against unexpected contingencies coming from within the body, as these, according to Triepel, will never reach even the yield-point of these tissues. The protection is here provided against contingencies coming from without, against injuries of external origin. It is a protection not against an internal, a physiological, calamity, but against an external, so to say pathological, contingency.

A sufficient number of readily available data for the study of our problem we find in researches upon complex tissues or organs. We shall begin with the bilateral mechanisms. Here are, in the first place, the kidneys. Every medical man knows now that one kidney can be removed with entire impunity, if the other kidney is normal. The amount and the composition of the urinary secretion remains practically unaltered and this even soon after the removal of the kidney. That can only mean that normally the kidney has an abundance of tissue which can do at a moment's notice at least twice the normal amount of work. From the experimental work of Tuffier, Bradford and others we know that at least two thirds of both kidneys may be removed without serious detriment to the animal's life and to the secretory function of the kidneys. At the same time we must remember that the normal secretion represents by no means the minimum amount of work of the kidney. We know that the average quantity of the urine as well as the normal quantities of its various constituents may be greatly reduced without any visible detriment. In fact there may be anuria for many days without any serious symptoms and perhaps also without serious consequences, if the anuria be not due to a disease of the kidney, but to such causes as hysteria, calculus, reflex, or compression. The margin of safety in the tissue of this eliminating organ amounts at least to twice its normal need.

This would seem to be an unreasonable luxury, a waste. But what a blessing. For a score of years, or more, in many of us the kidney is gradually losing some of its valuable material from one cause or another without any symptom, without a reminder sufficient to spoil our pleasure of life or to hamper our activities. Not until that luxurious surplus is approaching its exhaustion, do we get a warning. But then our work is mostly done and our time limit nearly reached.

Next we shall consider the lungs, an organ of supply and elimination of first order. We all know that life may continue though a great part of the lungs be destroyed, if only the disease which caused the destruction come to a standstill. We know that in some cases of pneumonia one lung can be entirely consolidated without seriously impairing the process of ventilation. Furthermore, a patient whose thorax was freely opened to evacuate a one-sided pleural abscess has after the opening less dyspnœa than before. In empyema as in pneumonia, it is essentially the infection and intoxication with their reactions which

cause the apparent disturbance in the respiratory mechanism and not so much the mechanical interference with the ventilation of the corresponding lung. Since the classical experiments of Regnault and Reiset many investigators have stated that compression of one lung or a unilateral pneumothorax exerts very little influence upon the respiratory exchange of gases. Hellin reported recently a series of experiments on rabbits in which the right lung was completely removed. The right lung of the rabbit has four lobes and is much larger in volume than the left; that means that more than one half of the lung tissue was removed. Most of the animals survived the operation and some lived a year and longer. Except for a temporary moderate dyspnœa lasting only an hour or two the animals were in a normal condition, and the respiratory quotient continued to be after the removal of the lung exactly as it was just before the operation. We see then that the normal process of respiration can be carried out with at least one half of the lung tissue and probably with a good deal less. We have here with regard to the quantity of tissue a factor of safety equal at least to two, which does not appear to be an excessive margin considering the importance of the function which that tissue has to carry out.

Of the bilateral organs of reproduction we know from numerous surgical operations that the removal of one ovary or of one testicle does not interfere in the slightest degree with the corresponding functions of the individual. For the female organs it has been frequently established that even a small part of one ovary is sufficient to carry on the function of menstruation and conception. In fact, there are a number of reliable cases on record in which pregnancy occurred after the removal of both ovaries, which cases were explained by the assumption that some particle of normal ovarian substance was caught in the ligature and retained in the body, and this fragment was then sufficient to carry out the function of ovulation and conception.

For the testicles we may safely assume also that a small fragment of one testicle left in the body would be capable of carrying on the function of reproduction. But I did not come across experimental or surgical data which directly bear out this assumption. There are definite data with regard to the secondary sexual characteristics in fowls. If in the process of castration some fragment of one testicle is left, the cock, according to Foges and others, does not lose the comb and other secondary sexual characteristics. However, these secondary characteristics are probably connected with the internal secretion of these organs, and their persistence might not be a sufficient proof for the persistence of the function of reproduction. At any rate, it is sufficiently evident, especially as will be seen later, that the tissues of the organs of reproduction are greatly in excess of the maximum need of the chief function of these organs.

Among the bilateral organs there are two whose functions are carried on exclusively by internal secretion, I mean the thyroid and the adrenal glands. We do not notice their activity while they are present, but we recognize their importance by the serious effects which follow their removal. The complete removal of both thyroid glands is followed either by acute symptoms of a tetanic type or by chronic states which are known under the names of myxœdema and cretinism. It is, however, a well-established fact that the removal of four fifths or even five sixths of both thyroids is not followed by perceptible consequences, which means that one fifth or one sixth of the entire gland is amply sufficient

to provide the body with the indispensable substance contained in the secretion of the gland. It was just on that account that at first the experimental results showing the importance of this gland were disputed by some observers: small accessory glands were hidden in some cases which made the apparently complete removal of both thyroids ineffective. The thyroid gland possesses, accordingly, four or five times more tissue than necessary for the complete maintenance of health and life of the animal.

In recent years some of the symptoms following the removal of the thyroid gland, especially the acute manifestations, are ascribed to the simultaneous removal of the epithelial bodies known as parathyroids. They are four in number. I do not know of a statement dealing directly with the question how much of the parathyroids has to be removed in order to bring out the pathological effects. However, in the dog the parathyroids are imbedded in the thyroids, two in each lobe, and some of the acute symptoms following the removal of the thyroids in dogs are ascribed as stated above, to the simultaneous removal of the parathyroids. By the removal of four fifths of the thyroids surely two and probably three of the parathyroids are also removed. But since the removal of four fifths of the dog's thyroids is not attended with any evil consequences, we may also conclude that a good deal of the substance of the parathyroids can be dispensed with without any ill effects.

For the suprarenal glands it is now well established that their removal is absolutely fatal to the animal. Death follows within nine to thirty-six hours after the extirpation of the glands, under conditions of low blood pressure, extreme muscular weakness and exhaustion. But the removal has to be complete; if one tenth of the glands or even less is left in the body, the animal shows no pathological symptoms. Here again, as in the thyroid, this fact caused the divergence of opinion which sprang up soon after Brown-Sequard made the discovery of the importance of this ductless organ. In many of the experiments bits of the tissue of that organ were left behind; besides, many an animal hides somewhere accessory organs of the same type. For the adrenals then it is evident that the body possesses indispensable tissue at least ten times as much as is necessary for the maintenance of normal life.

The brain is built on a bilateral plan. In former years, when following the lead of Flourens and as a reaction to the teachings of Goll, the brain was considered as a uniform organ, attending only to one function, some facts seemed to demonstrate indeed that there is a great excess of tissue in that organ, since the older experiments of Flourens and newer experiments of Goltz indicated that large parts of the brain could be removed without serious injury to life. To-day we know that the brain presents a collection of many organs, of many centers, the injury of each of which is followed by sensory or motor disturbances in definite areas of the body. As a whole, the bilateralness of the hemispheres does not mean the same as bilateralness in other organs, namely a duplication of tissue for one and the same function. One hemisphere attends to the needs of one side; for instance, the motor areas of the right arm or right leg are located in the cortex of the left hemisphere, and those of the left arm and left leg are located in the right hemisphere. The same is true of the subcortical centers and apparently also of the medulla oblongata.

To this rule there is, however, an exception for the motor organs having in charge such muscles or group of muscles which

normally contract on both sides simultaneously. The motor area of one side can take charge of the muscles of both sides. Such is the case with the motor areas of the respiratory muscles, the muscles of the larynx, of deglutition, etc. An injury to the motor areas of these muscles in one hemisphere only does not cause paralysis of these muscles. An instance well known to practitioners is the one-sided injury to the motor area of the orbicularis palpebrarum. The muscle, as a rule, is not paralyzed by such an injury, at least not when the muscles on both sides contract simultaneously. As is well known, the absence or presence of paralysis of that muscle in cases of facial paralysis serves as a means to diagnose whether the paralysis is of central or peripheral origin.

An example of an uneconomical principle, to use the expression of Verworn, we find in the bilateral innervation of certain viscera by the pneumogastric nerves. For instance, the normal rhythm of respiration is completely changed when both vagi are cut, whereas when only one vagus is cut, the respiration remains normal. Apparently one vagus nerve is amply sufficient to carry on the regulation of respiration. A similar condition obtains with regard to the heart beats. For certain animals, the dog for instance, the vagi carry on an inhibitory tonus. When both vagi are cut, the heart beats are considerably increased in frequency; when only one vagus is cut, the rate does not change. Here again a single vagus nerve is sufficient to carry on that inhibitory tonus. Still more striking is the following fact. After cutting both vagi, the animal dies within a day or two from aspiration pneumonia, whereas when only one vagus is cut, the animal not only survives the operation, but is for all purposes apparently perfectly normal. One vagus nerve then is amply sufficient to carry on all these functions; but the body is provided with two nerves. According to Verworn this should be an example of a violation of the principle of economy in the animal body and its existence should be denied *a priori*.

Further examples of the ample provision of the structures of the body with factors of safety we meet also in the organs of the body which are not built on the bilateral plan, the unsymmetrical organs. We shall mention here first the pancreas with respect to its internal secretion. It is now common knowledge that the complete removal of the pancreas leads to glycæmia and glycosuria. But here we note the fact that if a small part of the gland, say not more than one tenth, is left in the body, no ill effects follow such an extirpation. One tenth of that gland is capable of completely protecting the animal against glycosuria; but the body is, nevertheless, provided with ten times as much.

Another striking example is the liver. This organ has many important functions. It converts the sugar into glycogen; it converts the poisonous ammonia compounds into the comparatively harmless urea. It forms bile which carries out poisons from the body, removes waste products, assists in some way or another in the absorption of fats, aids in the digestion of proteids and what not more. But Ponfick found that the removal of one half of that organ practically does not interfere with the life of the animal, and the successful removal of even three fourths of the organ does not produce symptoms indicating that any of its functions are seriously interfered with. That organ then is provided with an abundance of active tissue considerably in excess of its normal requirements.

Similar striking examples of factors of safety we meet with in the luxurious construction of the gastro-intestinal canal.

The entire stomach or the greatest part of it has been removed in animals and man without interfering with digestion and nutrition. Of the small intestines large parts have been resected without serious consequences. In human beings the largest part removed measured, I believe, over three meters, and Erlanger and Hewlett have studied the metabolism of dogs seven or eight months after the removal of seventy or eighty per cent. of the movable part of the small intestines. Three fourths, then, of the small intestines are almost a luxury to the body. We need, not, perhaps, speak of the fact that surgeons have removed large parts of the colon without ill effects. From the present attitude of bacteriologists and physiological chemists towards the activities of the large intestines one is led to believe that the body might do best without any part of that organ. Be this as it may, it is quite sure that the digestive canal is provided with a good deal more structure than is required for the maintenance of its function.

Here we shall discuss briefly also the luxurious provision of the alimentary canal with digestive ferments. There are two proteolytic ferments: pepsin and trypsin, to which we may add also erepsin, a ferment found by O. Cohnheim in the mucous membrane of the small intestines and which is said to be capable of splitting albumose into amino acids. There are two amylolytic ferments: the ptyalin of the salivary glands and the amylopsin of the pancreas. As to lipolytic ferments, the steapsin of the pancreas is not the only one of that kind which reaches the contents of the digestive canal. Thus several investigators have recently confirmed the statement of Volhard that the fundus of the stomach secretes a lipase which is capable of splitting emulsified fat. Lipase is contained also in the liver and in the bile.

Now there are a number of experiments and clinical facts which go to show that digestion can continue in normal fashion even if one half or at least a good part of these ferments are eliminated from the digestive tract. Older and recent experiments have established the fact that the removal of the salivary glands has no effect upon the digestion. We know, on the other hand, that after removal of the pancreas or in cases of isolated destructive diseases of this organ the digestion of carbohydrates is not disturbed. Normally, therefore, there is a superabundance of amylase in the digestive canal. As to the proteolytic ferments, we have already mentioned that the complete removal of the stomach does not disturb digestion. Furthermore, in cases of achylia gastrica, in which the stomach secretes neither hydrochloric acid nor pepsin, the proteid digestion is apparently normal. On the other hand, we know that the elimination of the pancreas does not affect palpably the proteid digestion. With regard to lipase, clinical pathology was teaching that in cases of disease of the pancreas the stool contained fat, which would seem to indicate that in the absence of the pancreatic lipase no other lipolytic ferment was present in sufficient quantity to split completely the ingested fat. However, in a very recent study of Umber and Brugsch it was shown that the fat-splitting function is carried on even in the absence of the pancreas in a normal way.

We are then surely justified in claiming that the various digestive ferments exist in the alimentary canal in quantities far above the necessities for the digestion of a normal amount of food.

All the numerous organs and complex tissues which we have just passed in review are built on a plan of great luxury. Some organs possess at least twice as much tissue as even a maximum of normal activity

would require. In other organs, especially in those with an internal secretion, the margin of safety amounts sometimes to ten or fifteen times the amount of the actual need. An extreme degree of superabundance and actual wastefulness we meet with in the organs and functions having charge of the continuation of the species. Let us illustrate it by the following few data. The ovum exists for the purpose of reproduction. Assuming that the sexual function of a woman lasts forty years and assuming, further, that every ten months of these years would be taken up by a pregnancy, then only fifty ova would be required of the ovary. But assuming even that a regular menstruation is an essential and indispensable part of the sexual function, then five hundred ova would be the maximum that the function of reproduction could use. Nevertheless, we find that the ovary of the new-born female child possesses between 100,000 and 400,000 eggs, and at the time of puberty there are still about 30,000 ova ready to enter upon their possible mission. That is, the ovary contains at puberty sixty times more ova than the body could possibly ever employ. But there is an incomparably greater waste in the provision of the male germ. According to Rohde each ejaculation contains 226 millions of spermatozoa. Now we know that of all these legions only one single spermatozoon is required and only one can be used. What a marvelous waste of living cells for the sake of assuring the perpetuation of the species. But there are some attenuating circumstances. With a velocity of only 0.06 of a millimeter per second, with the dangers of crossing the sea of fatal acid vaginal secretions and with a resistance to the onward progress offered by the cilia of uterine epithelium swaying in the opposite direction, not too many of the storming millions stay in the race and have a chance to reach the goal. At any rate, it is not by economy, but by immense waste of cell life that the chance for continuation of the species is assured.

In striking contrast to the extreme luxuriousness of provision of tissue in the organs previously described stands out the comparative scantiness of cell tissue in some organs—if we may call them so—of the central nervous system. The centers of the medulla oblongata, for instance, present such minute bodies that hardly a part of any center could be injured without endangering the entire function. Any injury to the respiratory center suspends immediately and permanently the function of respiration. The possible existence of some respiratory centers in the spinal cord does not alter the practical result. The same applies to the center of deglutition. The blood pressure, as we shall see later, is provided with quite a large number of safety factors. However, the immediate effect of an injury to the vasomotor center is a dangerous drop in blood pressure, the restitutions and compensations over which the organism commands are not forthcoming until after a long interval. We may point out, however, that the central nervous system is provided externally with factors of safety against two of its main enemies: it is protected by a bony encasement against any physical injury and especially is the medulla oblongata well hidden away, and it is protected by an abundance of blood vessels against dangers of anæmia.

Following the old divisions of the organs of animal life in reproductive, vegetative and animal systems, we may say, perhaps, that the reproductive system is provided most and the animal system is provided least with factors of safety, while in the vegetative system, which in that regard occupies a middle position, those organs which seem to be less well differentiated,

like the organs for internal secretion, seem to be provided with a larger surplus of tissue.

The complex apparatus of circulation is well provided with factors of safety. In the first place, the animal body possesses a good deal more blood than it requires for its work. It is known by experimental evidence and clinical observations that nearly one half of the blood can be withdrawn without serious consequences to the life of the animal. As a further factor of safety in this regard we might register the ability of the blood to recover its loss very rapidly.

Furthermore, the capacity of the entire system of blood vessels in a completely relaxed state is again much greater than the volume of blood of the body. It is this difference between the volume of blood and the volume of the vessels which greatly facilitates the circulation of the blood and the proper nutrition of the various organs of the body. On the basis of this difference large quantities of blood can be thrown at once and with ease into the splanchnic region, into the skin or into the working muscles. After a local injury or infection in a very brief time for the sake of repair or defence hyperæmia sets in, and vessels which were not noticeable before become fairly visible. An instance of a similar order is the wide-spread institution of collateral circulation. Around an anemic focus blood vessels which previously were hardly visible become full and large to meet the threatening danger of necrosis of the neighboring anemic tissues. All these devices which spring into activity only under special exigencies, are manifestly factors of safety and are made possible by a superabundance of bloodvessels.

The difference between blood volume and capacity of vessels is an indispensable factor of the circulation, and its permanence is assured by many devices. Thus, for instance, any artificial increase of the volume of blood is immediately corrected through the chief eliminating organs, or through the secretory glands, or even by throwing some of the surplus serous fluid temporarily into the lymph spaces and serous cavities. Œdema, ascites and hydrothorax are sometimes not parts of the affliction, but means of repair.

Furthermore, existence of the difference between vascular capacity and quantity of blood is made possible only by a wonderful mechanism which controls in every part of the body the mutual adaptation of blood and vessel—the so-called vasomotor apparatus. It causes the dilatation of the vessels in the part of the body which requires and is to receive more blood, at the same time causing a constriction of the vessels in a part which can spare some of its blood. This mechanism is so important that it is again guarded by an abundance of factors to assure its safety. There is a vasomotor center in the medulla oblongata; when this is destroyed, a number of vasomotor centers in the dorsal medulla assume control; when they are eliminated, the sympathetic ganglia take over the command, and when they too drop out, the vascular wall itself attends to the proper regulation and adaptation of the capacity of the vessels to the volume of blood.

Finally, the chief motor mechanism of the circulation, the heart, is a clear instance of an organ provided with a superabundance of volume and force. Normally it is in a state of tonus and receives only a moderate volume of blood which it throws into the aorta with no great hurry and with an expenditure of only a moderate amount of energy. But at any moment it is ready to receive many times the usual volume of blood, is ready to double or treble the rate of its beats and is capable of developing nearly any amount of energy

which the situation might require of it. It is a wonderful, prompt, adaptive motor mechanism with a good reserve of force.

We have, then, in the circulatory system many instances of provisions with factors of safety to assure nutrition of all parts of the body in all states and conditions. An abundance of blood, a superabundance of blood vessels, a vast provision of factors for the safety of the adaptation of the two to one another and a great reserve of motor force for transportation and distribution of the blood.

The multiple mechanisms existing for the care of the vasomotor apparatus lead us to the following considerations. The internal motor organs of the body like the gastrointestinal canal, the heart, the uterus, etc., are provided with central motor innervations as well as with local motor mechanisms. In all cases it has been shown that the movements of the organs continue also after the severance of the connections with the central nervous system. Thus the heart continues beating after section of both vagus and accelerator nerves, the peristalsis of stomach and intestines continues after cutting the vagi and the splanchnics, and pregnancy and delivery take a normal course after complete destruction of the spinal cord. On the basis of these facts it is now generally assumed that the extrinsic innervations of these organs have only a regulating function, while the real motor function is invested in peripheral devices, be they of neurogenic or of myogenic character. This conclusion is obviously based on the supposition that the function of an organ is carried on only by a single mechanism. Hence the fact that the motor work is carried on after eliminating the extrinsic nerves seems to be sufficient evidence that they can not form an integral part of the motor function.

These conclusions are fallacious. There is an abundance of instances in which one and the same function is cared for by more than one mechanism. But we need only refer to the vasomotor apparatus. It was known before and it has been very recently conclusively demonstrated again by Magnus that, after eliminating the influences of the sympathetic and the central nervous system, the blood pressure is well taken care of by the peripheral mechanism of the walls of the blood-vessels. Nevertheless, nobody doubts that the vasomotor centers are integral parts of the vasomotor mechanism. Why this difference of views for the different organs of the body?

The subject is evidently an important one; but we shall not enter into a further discussion of it. The remarks were made to illustrate the importance of the conception that in the animal body one function is not infrequently cared for by more than one mechanism. It is capable of profoundly affecting the views on many vital biological problems.

We shall cite a few more instances in which two or more parallel mechanisms exist for the accomplishment of one function. I may be permitted to mention in the first place the function of deglutition. As was shown by us about twenty-five years ago, fluids and semifluids are squirted down from the mouth to the cardia by the force of the contraction of the mylohyoid muscles, but they can also be carried down by the peristalsis of the œsophagus. Of the latter there are again, as I have recently shown, two kinds: a primary peristalsis which runs independently of the integrity of the œsophagus and a secondary peristalsis which is closely connected with the integrity of the tube and which is more resistant to certain detrimental influences. It will probably be shown before long that the œsophageal wall alone is also capable of contributing to the function of carrying the food down to the stomach.

The function of the pancreatic secretion seems to be an instance in which mechanisms of a different type are sharing in its management. It has long been established that the pancreatic secretion stands under the influence of the central nervous system. Recently it was discovered by Bayliss and Starling that an intravenous injection of secretin causes a considerable increase of pancreatic secretion. Secretin is an extract made of the duodenal mucosa with an addition of hydrochloric acid. It is assumed that this substance is produced normally when the acid chyme comes in contact with the mucosa of the duodenum, and that by its absorption into the circulation it is one of the normal causes of pancreatic secretion. Now the effect of the secretin seems to have nothing to do with the nervous system, since the injection is active even after all connections with the nervous system are destroyed. On the other hand, in cases of achylia gastrica, in which the stomach is devoid of all secretion, the pancreatic secretion is apparently normal, as the digestion of proteids remains undisturbed. But since in these cases there is no secretion of hydrochloric acid, secretin ought to be absent; here the pancreatic secretion is probably attended to properly by the other partner in the management of the function, that is, by the central nervous system.

A double management of partners of a different type exists probably also for the mammary secretion. There is sufficient evidence that the secretion of milk is under the influence of the nervous system. Nevertheless, the secretion continues after all nerves going to the mammary glands are cut. The milk secretion in the latter case is probably kept up by a stimulation through an internal secretion provided by the reproductive organs. Internal secretion is probably a coexisting factor in many functions of the body.

Furthermore, there are instances in which one function is cared for by two separate organs. The function of digestion of proteids in the alimentary canal is carried on by two separate organs with a different chemical activity: the pancreas and the stomach. The trypsin of the pancreas digests proteids in an alkaline medium, while the pepsin of the stomach is active only in an acid medium.

An arrangement of a similar character we meet with in the organization of the function of the defence of the body carried on by the white cells against foreign invaders. This cellular army of defense is made up of two types: the microphages, the polynuclear leucocytes whose abode is in the bone marrow; and the macrophages, the large mononuclear cells which have their barracks in the lymph nodes and lymphoid tissue. According to Opie one of the effectual weapons of these warriors is their intracellular proteolytic ferments. But the ferment of the microphage is active in an alkaline medium, while that of the macrophage requires for its activity an acid medium.

As factors of safety we may consider also the assistance which one organ lends to another or the vicariation of one organ for another. For instance, the assistance which the sweat glands render to the kidney in the process of elimination of a surplus of water, or the vicariation of the mucous membrane of the intestinal canal in the process of elimination of urea. Such mutual assistance of the organs is a widespread institution in the animal body and assures the safety of many vital functions.

Returning to the organs which are provided with a large surplus of active tissue, the question confronts us: which is the mode of distribution of the normal activity of an organ among its luxurious tissues? Since the activity of such organs, as we

have seen, is far below the capacity of their tissues, the distribution could occur only in two ways. Either some parts of the tissues work to their full capacity, while the other parts remain idle, being only in readiness for emergencies—like the unemployed vice-president of some organization —or all elements of the organ take equal part in the work, each tissue element employing only a fraction of its capacity for work. The last alternative is probably the more frequent mode of distribution. There are, for instance, probably no totally inactive glomeruli and tubules in the kidneys, no inactive liver cells, no thyroid epithelial cells entirely without colloidal substance, but the epithelium of the glomeruli and tubules work only one half of their capacity, the islands of Langerhans work less than one tenth, the vesicles of the thyroid about one sixth of their capacity, etc. For the muscles of the heart it is generally assumed that all the fibers take part in every contraction, but that they work normally only a fraction of their capacity. On the other hand, there are organs in which surely parts of the tissue do not take active share in the work, unless called upon under special circumstances. In the ovaries, for instance, surely only one ovum becomes fertilized, while all the others are only on the waiting list. An instructive instance is the mode of distribution of work among the respiratory muscles. In normal inspirations, for instance, we find only the diaphragm alone at work. When somewhat deeper breathing is required, the inspirations are supported by the levatores costarum and the scaleni. Furthermore, in labored respirations also the sternohyoid and the posterior superior serrati become engaged in the work, and when the difficulties become still greater, still other groups of muscles enter into the struggle. In other words, the different groups of muscles which are designated to do the work of inspiration are not engaged in it in the manner of partners of equal standing, but enter upon their duties as a series of vice-presidents or rather as a series of reserve forces. On the other hand, in the diaphragm probably all the muscle fibers are engaged in the work of each inspiration at all times, employing only a fraction of their capacity in normal or shallow inspiration and working to their utmost capacity in dyspnœa or asphyxia. We see, therefore, in one and the same function both modes of distribution of work well represented, one muscle steadily at work with all fibers, like a heart, adapting the degrees of their energies to the various requirements of their work, and a number of groups of other muscles, acting as graded reserve forces, idle but ready for emergencies—instructive examples of luxurious factors of safety.

In the foregoing we have brought forward a sufficient number of instances in which various parts of the living organism are provided with a superabundance of material and energy to warrant the comparison of the organism with a machine with regard to the provision with factors of safety.

One of the fundamental differences between living organisms and human-made machines is that the former carries in it the germ for self-propagation, while machines have to be made by human hands. As a further difference between the two constructions we may perhaps consider the phenomenon of self-repair. Possibly the phenomenon of self-repair in the organism is closely allied with the phenomenon of self-propagation. The same source which provides the organism with a mechanism for a reproduction of the entire body provides its parts with a mechanism for regeneration of these parts. Reproduction and

regeneration might have a common cause. At any rate, self-repair distinguishes the organism from the machine. If parts of a machine yield to stress and the factors of safety become exhausted, the machine would surely break down, unless it is repaired by human hands, just as it is made by human hands. As far as I know, no machine has yet been invented which is provided with devices for a continual self-repair. In the living organism self-repair is a wide-spread function of living tissues and organs. It is a dormant force, a reserve force, which springs into immediate activity as soon as any injury is inflicted. It is a factor of safety peculiar to the living organism. It manifests itself in the forms of regeneration and hypertrophy of tissues and organs, and also in the functional forms of inflammatory reaction, of substitution, vicariation and adaptation. And here it is interesting to observe that self-repair does not set in only when the margin of safety is exhausted, when there is an actual need for repair, but already when only the integrity of the factors of safety is encroached upon. Self-repair is a factor of safety also for the protection of the factors of safety. When, for instance, one kidney is removed, the hypertrophy of the secreting elements begins a few hours later, although the urinary secretion was hardly impaired. It is an attempt to reprovide with luxurious tissue. The liver cells regenerate, the thyroid, the adrenals and other organs hypertrophy and regenerate even when the preceding injury was not extensive enough to affect the function of these organs. It is, as stated before, an attempt to restore the factors of safety. A heart working above normal becomes hypertrophied even if it has not yet met with any obstacles; it is a provision in time against possible shortcomings; it is a repair of the factors of safety. This is a very interesting field, but it would lead us too far to enter upon a detailed discussion of the various aspects of the subject. We would only call attention to two exceptions. One is the very scanty repair which takes place in the organs of reproduction. But the affluence is here so immense that the organs may safely forego the benefits of self-repair. The other exception concerns the nerve ganglia; nerve cells as a whole do not regenerate. We have learned above that the ganglionic masses of the central nervous system are scantily provided with factors of safety. Here we learn that they are also deprived of the great aid afforded by regeneration. There is some functional self-repair in the central nervous system. Other centers assume the work of the lost ones; adjacent tissues become educated to the work; dormant centers of the opposite hemispheres wake gradually up to their new missions. But all these substitutes are insufficient satisfactorily to replace the lost function, not to speak of a provision for factors of safety.

Here we must recall that the lack of regeneration applies only to the nerve cells. The nerve fibers, on the other hand, especially those of the peripheral nerves, show rather a very active regeneration.

The foregoing review shows, I believe, conclusively, that the tissues and organs of the living animal organism are abundantly provided with factors of safety. The active tissues of most of the organs exceed greatly what is needed for the normal function of these organs. In some organs the surplus amounts to five, ten or even fifteen times the quantity representing the actual requirement. In the organs of reproduction the superabundance and waste of tissue for the sake of assuring the success of the function is marvelous. Furthermore, the potential energies with which some organs, like the heart, dia-

phragm, etc., are endowed, are very abundant, and exceed by far the needs for the activities of normal life. The mechanisms of many functions are doubled and trebled to insure the prompt working of the function. In many cases the function of one organ is assured by the ready assistance offered by other organs. The continuance of the factors of safety is again protected by the mechanisms of self-repair peculiar to the living organism. We may then safely state that the structural provisions of the living organism are not built on the principle of economy. On the contrary, the superabundance of tissues and mechanisms indicates clearly that safety is the goal of the animal organism. We may safely state that the living animal organism is provided in its structures with factors of safety at least as abundantly as any human-made machine.

The safety of a mechanism is increased, as we have stated before, also by an economic handling of the expenditure of its energy. The expenditure of energy by the living animal organism consists chiefly in the work which it performs, that is the contractions of the muscles. Of the involuntary work of the body it is only the action of the heart and the respiratory muscles of which we possess a knowledge of some available facts. The heart, although capable of doing a great amount of work, is normally kept down to perform only the most indispensable duty. The inhibitory tonus exercised by the vagi prevents the heart from beating too rapidly and too strongly, when it is not required; and the vascular reflexes carried from the heart or aorta to the vasomotor centers regulate the vascular circulation so as not to offer too much resistance on the one hand, and not to fill up the heart with too much blood on the other hand.

The respiration is normally carried out only by one muscle, the diaphragm, and this works only with a fraction of its capacity, the distention of the lungs producing an inhibitory stimulus preventing the muscle from overaction.

The contractions of the skeletal muscles being regulated chiefly by the will, offer insufficient opportunities for a study of the normal regulation of expenditure of energy emanating from this source. There are, however, two facts which are instructive and deserve to be mentioned. One is the provision of the muscle with the sense of fatigue setting in with overexertion; it might serve as a guard against overwork, against exhaustion of the muscles. The second fact is the provision of the muscular innervation with inhibitory impulses for antagonistic muscles; it prevents harmful or even only unnecessary contractions. In other words, it prevents the muscles from an unnecessary expenditure of energy.

While the facts are not many, they are sufficient to indicate the tendency of the organism to be economical in its expenditure of energy.

We now arrive at the examination of the principles of governing the supply of the organism with energy. A machine is provided with fuel far above the necessity for the performance of the expected minimum work; it has to be in readiness for unforeseen exigencies. How about the organism? The supplies for the animal machine consist of inorganic salts, water, oxygen and food. Our knowledge of the laws governing the supply and expenditure of water and inorganic salts for the animal organism are still too imperfect to be utilized here for the elucidation of our problem. We have to restrict our discussion to the supply of food and oxygen. The supply of food is influenced so much by the will of the animal that it is difficult to obtain facts permitting only one interpretation. For instance, the amounts of food taken by men in all parts of the world can not

be taken as the normal quantity which the body requires, because, as Chittenden and his school say, this amount is dictated by habit and not by actual necessity. The latter found, as stated before, that with a proteid diet lower than the one employed in the current diet of man, a number of men continued their normal life without special incidents. As a result of this observation these investigators assume that the minimum proteid diet is the normal one and advocate its adoption as a standard diet. The finding that men can continue to live with a certain minimum is a fact; the assumption that this minimum is the actual requirement of the organism, is, however, only a theory, and a theory which decides that in contrast to a human-made machine the animal machine should be provided with a minimum supply of energy just sufficient for the average daily incidents and daily work.

Neither can we, on the other hand, look upon the facts which were brought together in this lecture as an absolute proof that the animal's supply of energy ought also to be provided on the same plan of superabundance. It may be claimed that the animal's welfare is best cared for by observing stringent economy in the supply of its energy.

Luckily, however, the supply of oxygen to the organism is a process practically entirely independent of the will, and therefore a fact or two which we find here may well throw some light upon our problem.

One fact here is indeed instructive. It is a frequently made and well established observation that the oxygen of the inspired air may be reduced to about one half of its normal amount without causing any ill effects whatsoever. The oxygen of the atmospheric air amounts to about 21 per cent., and it may safely be reduced to about 11 per cent. or 10 per cent. Nature then supplies oxygen to the animal body in an abundance amounting at least to twice the maximum quantity which the normal condition of life may require.

Furthermore, even with an atmosphere greatly reduced in oxygen the body is capable of attending to work so strenuous that it may cause a consumption of oxygen perhaps five times the amount normally used up during rest or light work. This occurs, as was demonstrated in the interesting experiments of Zuntz and his co-laborers, in climbing mountains and carrying at the same time considerable loads at altitudes with a barometric pressure of less than 500 millimeters of mercury.

We should also remember another instructive and characteristic fact, namely, that the venous blood is comparatively rich in oxygen, possessing often nearly two thirds of that present in the arterial blood, which means that the oxygen carried in the arterial and capillary blood is greatly in excess of the requirements of the cellular tissues.

Finally, another interesting point is that labored breathing sets in long before the tissues are in actual need of oxygen. Dyspnœic breathing is a device to cause a refilling of the exhausted surplus of oxygen by a more efficient pulmonary ventilation. The hard-working skeletal muscles which consume an undue amount of oxygen produce at the same time a substance which stimulates the respiratory center to greater activity and thus to a more liberal provision of oxygen. This is again a sort of self-repair of the loss to the factors of safety.

All this is sufficient evidence that as far as oxygen is concerned the supply of the body with energy is certainly not conducted on the principle of stringent economy. On the contrary, abundance is the guiding rule here, as it is in the provisions of the body's structures.

We now again return to the question of

supply of food. The presence of an abundant supply of glycogen and fat in all animal bodies seems to me to be a sufficient indication that carbohydrates and fats are not supplied on the principle of stringent economy. Fuel material is here abundantly stored up not so much for its immediate use but essentially for use in unforeseen exigencies. As far as I know the claim has not yet been raised that these savings deposits are due only to acquired habits of ingesting too much of the mentioned forms of food.

With regard to the proteid diet, however, the question of the normal supply, as we have repeatedly mentioned, is not above discussion. In a recent review of the subject by Benedict one of his precise statements reads: "dietary studies all over the world show that in communities where productive power, enterprise and civilization are at their highest, man has instinctively and independently selected liberal rather than small quantities of protein." Chittenden, on the other hand, says: "all our (experimental) observations agree in showing that it is quite possible to reduce with safety the extent of proteid catabolism to one third or one half that generally considered essential to life and health." And then adds: "It is obvious * * * that the smallest amount of food that will serve to maintain bodily and mental vigor * * * is the ideal." As valuable as the facts which Chittenden and his co-laborer found may be, they do not make obvious their theory that the minimum supply is the optimum—the ideal. The bodily health and vigor which people with one kidney still enjoy does not make the possession of only one kidney an ideal condition. The finding that the accepted standard of proteid diet can be reduced to one half can be compared with the finding that the inspired oxygen can be reduced to one half without affecting the health and comfort of the individual. But nobody deduces from the latter fact that the breathing of air so rarefied would be the ideal. Chittenden suggests that a greater use of proteid might be the cause of many ills, for instance of gout and even of tuberculosis and cancer. I shall not attempt to discuss the merits of this theory as far as the causation of tuberculosis and cancer is concerned. As to the causation of gout, one of Chittenden's most able supporters, Otto Folin, has pointed out that at best this could be claimed only for eating crude meat but not for an ingestion of protein in general, because the latter becomes converted into harmless urea, as Folin says. I would add that if we should avoid eating meat because some of us might sometimes get gout, we should surely avoid eating carbohydrates because it sometimes leads to diabetes, and avoid eating fats because it often leads to various mischiefs. What then shall we eat with absolute impunity?

But I wish to recall here one fact, namely that the administration of too large a dose of thyroid extract leads to a pathological condition similar in character to that of Graves's disease. The normal body nevertheless possesses, as we have shown above, a great surplus of thyroid tissue without causing any thyroidism. That some isolated metabolic product might do some harm when artificially incorporated into an animal is far from being fair evidence that this normal product of the animal mechanism does harm there when in its normal connections. Metabolic products are present in great abundance in all healthy individuals without causing mischief.

The situation seems to me to be this. All organs of the body are built on the plan of superabundance of structures and energy. Of the supplies of energy to the animal we see that oxygen is luxuriously supplied. The supply of carbohydrates

and fats is apparently large enough even to keep up a steady luxurious surplus. For the supply of proteid we find in the actual conditions of life that man and beast, if they can afford, provide themselves with quantities which physiological chemists call liberal. This may or may not be the quantity which nature requires and approves of. Experiments have shown that a number of men subsisted on the half of such quantities. This latter might be an indispensable minimum, just as there is an indispensable minimum for all other luxuriously endowed provisions of the animal organism, and the liberal ingestion of proteid might be another instance of the principle of abundance ruling the structures and energies of the animal body. There is, however, a theory that in just this single instance the minimum is meant by nature to be also the optimum. But it is a theory for the support of which there is not a single fact. On the contrary, some facts seem to indicate that nature meant differently. Such facts are, for instance, the abundance of proteolytic enzymes in the digestive canal and the great capacity of the canal for absorption of proteids. Such luxurious provision for digestion and absorption of proteids is fair evidence that nature expects the organism to make liberal use of them. Then there is a fact that proteid material is stored away for use in emergencies, just as carbohydrates and fats are stored away. In starvation nitrogenous products continue to be eliminated in the urine which, according to Folin, are derived from exogenous sources, that is from ingested proteid and not from broken-down organic tissues. An interesting example of storing away of proteid for future use is seen in the muscles of the salmon before they leave the sea for the river to spawn. According to Miescher the muscles are then large and the reproductive organs are small. In the river where the animals have to starve the reproductive organs become large while the muscles waste away. Here in time of affluence the muscles store up nutritive material for the purpose of maintaining the life of the animal during starvation and of assisting in the function of reproduction. This instance seems to me to be quite a good illustration of the rôle which the factor of safety plays also in the function of the supply of the body with proteid food. The storing away of proteid, like the storing away of glycogen and fat, for use in expected and unexpected exceptional conditions is exactly like the superabundance of tissue in an organ of an animal, or like an extra beam in the support of a building or a bridge—a factor of safety.

I therefore believe that with regard to the function of supply of tissue and energy by means of proteid food nature meant it should be governed by the same principle of affluence which governs the entire construction of the animal for the safety of its life and the perpetuation of its species.

Before concluding I wish to add the following remark. It seems to me that the factors of safety have an important place in the process of natural selection. Those species which are provided with an abundance of useful structure and energy and are prepared to meet many emergencies are best fitted to survive in the struggle for existence.

S. J. Meltzer
Rockefeller Institute for Medical Research

Scientific Books

Some Recent Bibliographies of Geology

Two very valuable bibliographies of interest to all workers in geology have recently been issued. The first is Mr. F. B. Weeks's 'Bibliography and Index of North American Geology, Paleontology, Petrology and Mineralogy' for the years 1901–5, inclusive. It constitutes

Bulletin 301 of the U. S. Geological Survey, and includes approximately 6,400 titles. This certainly speaks well for the industry, at least, of American geologists. In glancing through the pages of the book one is struck with the large number of papers relating to economic geology. At the same time the amount of work done in paleontology, petrology, and the various abstract branches of the science, seems to have been only relatively and not actually less than in any preceding period of equal length. The bibliography follows in style Mr. Weeks's previous and well-known annual contributions.

The second report constitutes Bulletin 6 of the new (fourth) series of the Ohio Geological Survey. It consists in the main of a subject index to the publications of the various geological surveys of Ohio and is the work of Alice Greenwood Derby. It is supplemented by a brief and incomplete bibliography of publications relating to the geology of Ohio, other than those of the State Geological Survey, prepared by Mary Wilson Prosser. There is an unusually interesting preface prepared by the late state geologist, Edward Orton, Jr.

The Ohio bibliography differs entirely in character and scope from Mr. Weeks's paper noticed above. It is none the less well conceived and will be exceedingly useful. It is one of the unfortunate features of state geological survey work that the investigations are rarely continuous, and the publications are issued in various different forms and series from year to year. It is exceedingly difficult to keep track of them, and even more difficult to secure complete sets. In Ohio publication began in 1836, and there have been four successive and distinctly organized surveys. The reports have been prepared, printed and distributed under laws which have been changed from time to time, and despite the large aggregate sum spent in publications, many important libraries find it impossible to purchase full sets of the reports. Under the circumstances a complete index of the reports is particularly welcome. If it had included even brief abstracts, such as Mr. Weeks includes in his bibliographies, it would have been even more welcome. As it is, the bulletin will be of great service pending the publication of a complete dictionary catalogue, which will doubtless be some time necessary.

H. F. BAIN

URBANA, ILL.,
February 19, 1907

Mars and its Canals. By PERCIVAL LOWELL. Illustrated. New York, The Macmillan Company. 1906. Pp. xv + 393. 8vo.

'To G. V. Schiaparelli, the Columbus of a new planetary world, this investigation upon it is appreciatively inscribed'—so reads the dedicatory page of this handsomely printed volume, which is a storehouse of observation and theorizing concerning those features whose study Schiaparelli was so instrumental in inspiring. Whatever may be any astronomer's opinion regarding the degree of credibility to be assigned to various observations of the surface features of Mars, and whatever may be that astronomer's opinion of the validity of Lowell's deductions from those observations; no reader of this book can fail to recognize the serious earnestness of its author and his sincere belief in the scientific conclusiveness of all the varied arguments advanced to account for surface markings and phenomena that they present.

While this book is published as a popular exposition of the most recent investigations, it presents practically all that is known, or thus far suspected, presumably, concerning this planet and its inhabitants. It is divided into four parts.

Part I. is a description of its *natural features, i. e.,* those bearing closest resemblance to the earth in form and development. Here are outlined the advantages of good-seeing and the need to go to out-of-the-way parts of the earth to find transparent atmosphere: a bird's-eye view of past Martian discovery; a description of the polar caps, the white spots, the climate and weather, mountains and clouds, color-tinted areas, and vegetation. This part closes with a summary, occupying pages 159–170, in which are explicitly laid down and numbered 'thirty-nine articles of Martian scientific faith' presented as definite,

undeniable facts of accurate observation. The rest of the summary is devoted to showing how these articles dove-tail together in mutual confirmation.

Part II. describes what the author calls 'Non-natural Features,' by which he means those which have the least analogy to features on the earth, and which differ most from what our terrestrial experience would lead us most naturally to expect. In this category he places the canals, and describes their system and their gemination, and presents arguments to substantiate their objectivity as opposed to the diplopic, or the interference, or the illusion theory. A full account of the double canals is given, also of the canals in the dark regions, of the oases, of the 'carets' on the borders of the great diaphragm; and a description of Lampland's success in photographing thirty-eight canals, the doubling of Nilokeras and a snowfall, together with the more prominent 'continents,' 'seas' and 'oases.'

Part III. deals with the 'Canals in Action,' under the headings Canals: kinematic, Canal Development Individually Instanced, Hibernation of the Canals, Arctic Canals and Polar Rifts, Oases: kinematic. The purpose of this section and also of Part IV. is to show that the canals are real water arteries for the distribution of the melting polar caps to the arid equatorial regions, and to the constitution and purpose of the canals and oases in this scheme, with arguments in support of the hypothesis that life, sentient and vegetable, does exist on Mars.

The book is copiously illustrated, and closes with an index of nine pages.

Herman S. Davis

SOCIETIES AND ACADEMIES

THE TORREY BOTANICAL CLUB

The second stated meeting for the year 1907 was called to order at the Museum Building of the New York Botanical Garden at 3:30 o'clock P.M. on January 30, 1907, with Vice-president Professor L. M. Underwood in the chair. Twenty-three persons were present.

The scientific program was as follows:

Experiences on the Island of Jamaica during the Earthquake of January 14, 1907: Dr. M. A. Howe.

A trip for the collection and study of marine algæ and other plants brought Dr. Howe to the island of Jamaica on December 14, and he was on the island during the recent earthquake. An interesting account was given of his experiences at that time

New or Rare Mosses from Jamaica: Mrs. N. L. Britton.

Mrs. Britton exhibited some of the most interesting mosses collected in Jamaica, showing several genera and subgenera, not heretofore known in the West Indies, and several new species, and also indicated some reductions of names to synonyms. Specimens of types of Jamaican species were also shown from the Mitten Herbarium and one of Miss Taylor's drawings of a new species and subgenus.

The Probable Function of Tannin in Galls: Dr. Melville T. Cook.

The origin, chemistry and uses of tannin have been studied very extensively, but other phases of the subject have received comparatively little attention. This is especially true concerning the functions which it serves in the plant. It is usually very abundant in diseased tissues, such as insect galls, fungus galls, fungus spots, etc. In insect galls it is developed very early and in some cases it appears to result in the gall-makers moving to other parts of the plant. It is also formed in fungus-galls, frequently completely surrounding the point of rupture. In such fungus spots as those produced by *Cercospora* the successive circles are due to the depositing of tannin within the tissues. The author has made extensive studies on the anatomy of both insect and fungus galls and is now conducting a series of physiological experiments.

C. Stuart Gager,
Secretary

SPECIAL ARTICLES

THE LIMITATIONS OF ISOLATION IN THE ORIGIN OF SPECIES

Any adequate consideration of the bearing of the geographical distribution of organisms

upon the problems of evolution, especially of the origin and preservation of incipient species, should take into consideration all types of environment and all groups of organisms. The discussion which has continued for some time in the pages of this journal with especial reference to the significance of isolation on the origin of species has drawn its data very largely from the distribution of land and fresh-water vertebrates and has been in the main carried on by systematists who are specialists in these fields. But no insignificant part of the total organic evolution and specific differentiation has been accomplished in other phyla and in other environments. The data of distribution from the littoral, pelagic and abyssal areas of the sea, of the microfauna and flora of fresh water, and of the lower as well as the higher groups of organisms, from widely ranging as well as narrowly limited species and especially from groups in which a high degree of specific differentiation has been attained, such, for example, as the Diatomaceæ, the Radiolaria and the Coleoptera, all have some bearing on the problem unless, as some of the physiological school would have us believe, all wisdom is derivable only from pedigree cultures.

Some familiarity with the microfauna and flora of fresh water and with the pelagic fauna of the Pacific has brought to my attention a series of facts which, with considerable uniformity, indicate a degree of *coincident distribution of related species* which stands in strong contrast with the wide-spread isolation of related species and subspecies of birds and mammals to which attention has been drawn in previous discussions.

The range of material available for demonstration of this tendency is indeed great. The stimulus of the Kiel school of planktologists has led to the investigation of scores, if not hundreds, of lakes and streams, and the publication of extensive lists of their fauna and flora. Recent oceanic explorations in the several oceans have thrown a flood of light on the distribution of pelagic organisms.

The investigation of the microfauna and flora of fresh water, both limnetic and littoral, has demonstrated that its constituent organisms are to a very large degree cosmopolitan. As an illustration of this fact one has but to compare the lists from various localities. The abundant species are very widely represented. The number of rare species reported from any locality is largely a function of the thoroughness and the extent of the examination. About 50 per cent. of the protozoa and rotifers reported from the Illinois River have also been reported from the Elbe, and about 60 per cent. of the rotifers from the Oudy. The differential species, barring a considerable percentage resulting from synonymy, are almost wholly of known wide range but of relative rarity, and may be expected in most aquatic environments of the north temperate zone on long search. As a result of this cosmopolitan distribution most of the known species of a genus are wont to be found in a single locality. An excellent illustration of this phase of the question appears in Penard's splendid monograph of the fresh-water Rhizopoda in which he lists, from Geneva alone, 216 of the 232 known species of this group, and 91 of these from a single locality! He found certain recognizable habitats, each with its more or less peculiar fauna, such, for example, as the sphagnum, the sylvicolous, and abyssal faunas. These include, however, only forty-nine species limited to any special habitat. The genus *Difflugia,* for example, with thirty-seven species, has but nine whose distribution is restricted to a particular habitat; the others may occur in any type of habitat.

In the autumnal months from September to November, streams and lakes rich in organic matter exhibit a marked increase in the ciliate protozoa, especially of the Holotricha. This is especially marked in the Illinois River, and at such times many species of the genera *Prorodon, Lionotus, Lacrymaria, Didinium, Coleps, Nassula* and *Chilodon* occur coincidently. Species of other genera of ciliates such as *Stentor, Euplotes, Vorticella, Zoothammium* and *Epistylis* occur coincidently at this season. Thus Dr. Volk has recently found in the Elbe from September 9 to October 11, 73 per cent. of the *total* number of valid species, of the genera above named,

admitted by Bütschli in his Thierreich monograph. The species which Dr. Volk lists from the Elbe near Hamburg exhibit a high degree of coincident distribution. His data indicate that about 85 per cent. of the recorded species in the genera named are found in the *same* habitats and that 80 per cent. of these were taken at some time in the period named on the same day. Within the genus *Vorticella,* represented by eighteen species, the average percentage of coincident occurrence on the same day in all the collections was 50 per cent.; in *Stentor,* 75 per cent. Among these instances of coincident distribution of the species of a genus are numerous cases of the *coexistence of the most closely related species in the same habitat.*

The fresh-water Rotifera are notoriously cosmopolitan in distribution. About 92 per cent. of the 246 species reported by Professor Jennings from the United States are found on other continents. The species of the group exhibit in common with the fauna and flora with which they are associated, certain well-defined restrictions in distribution, due to environmental factors combined in various types of habitat, such as open water, and shore vegetation. The genus *Brachionus* is found predominantly in open water of warm shallow ponds and streams where it occurs in enormous numbers during a large part of the year. After eliminating synonyms arising in large part from failure to examine literature or to ascertain the seasonal form-cycle, there remain at least about twelve common forms of specific value in this genus along with a considerable number of so-called variants. One of these species, *B. dorcas,* is predominantly a winter species, and another *B. militaris,* predominantly a shore and vegetation-loving species. The remaining forms are all typical members of the limnetic fauna of warm shallow waters and *usually together throughout a large part of the summer,* in many parts of the world. In common with practically all other organisms of the limnetic fauna and flora these species of *Brachionus* run a rhythmical course of fluctuating recurrent cycles of increase and decrease in numbers of three to six weeks' duration. A single instance drawn from the records of the Illinois State Laboratory of Natural History of my unpublished statistical work upon the plankton of the Illinois River will suffice to illustrate the character of these rhythmical fluctuations and the relations which they bear to the breeding periods of *Brachionus.* During the rise of the 'pulse,' parthenogenesis prevails, and at its maximum and during its decline sexual reproduction appears as indicated by the presence of male eggs, males and winter eggs. The imperfections of the plankton method, the difficulty of specific identification of male rotifers and detached eggs introduce a considerable degree of incompleteness in these statistical records. The trend of the statistics remains, however, significant.

BRACHIONUS ANGULARIS.—NUMBER PER CUBIC METER ILLINOIS RIVER, 1896.

Date.	Females with Partheno-genetic Eggs.	Females with Male Eggs.	Females with Winter Eggs.	Males.	Total, Eggs and Adults.
July 29	4,560	0	0	0	27,072
Aug. 1	7,747	0	0	0	69,342
Aug. 8	18,696	0	0	0	81,320
Aug. 12	29,106	103,950	594	0	773,982
Aug. 21	9,496	3,561	0	1,187	161,432
Aug. 29	3,775	0	0	0	28,355
Sept. 5	2,385	0	0	0	16,536

Within the breeding period of *B. angularis* covered by this table, *Brachionus pala, B. amphiceros, B. bidens* and *B. bakeri* were also found with male or winter eggs or both, and *B. cluniorbicularis, B. melhelmi, B. militaris, B. mollis, B. punctatus, B. rhenanus, B. rubens* and *B. tuberculus* ran a like cycle of smaller amplitude, but no males or winter eggs were found attached to the individuals counted. No effort was made during the collection of these statistics to determine whether these remaining species were breeding sexually or not. It is quite possible that they were. The list includes a number of instances of most closely related couplets. Opinions differ as to the specific, subspecific or varietal standing of some of the forms in the list.

We have then in *Brachionus* coincident distribution of nearly all the species of the genus

and contemporaneous sexual reproduction in five species or varieties, in this instance, with the possibility that the remaining eight may also be in sexual activity. There is little possibility of any horizontal stratification separating the species here, as the waters of the Illinois River are shallow (three to ten feet) and are stirred by current and diurnal movements. These same species occur together, moreover, in shallow bottom-land lakes but a few inches in depth.

Closely related species and varieties of *Brachionus* thus live together in the same habitat and breed at the same times, with no external barriers to prevent their swamping out.

The fresh-water Copepoda afford an excellent test for the contemporaneous breeding of closely related species having coincident distribution, since the eggs are carried for some time by the female during their development and the breeding periods of the several species can thus be determined. There are six species in the subgenus *Cyclops* which occur in the Illinois River and are often found breeding in the same seasons. Two of the most closely related, *C. edax* Forbes and *C. leuckarti* Claus, are found breeding coincidently in August. The other members of the subgenus, *C. viridis* Jurine and *C. bicuspidatus* Claus have overlapping breeding periods in the spring, and the two varieties of *C. viridis,* v. *insectus* Forbes and v. *brevispinosus* Herrick breed coincidently throughout the summer. *C. serrulatus* Fischer and *C. prasinus,* closely related species of the subgenus *Eucyclops* have a wide distribution in the United States and Europe and are frequently found in the same collections. *Diaptomus pallidus* and *D. siciloides,* two most closely related species of Calanidæ, are found together in about equal numbers, breeding at the same seasons in the Illinois River.

The limnetic fauna and flora thus afford numerous instances not only of the coincident distribution of closely related species, but as well of their contemporaneous breeding. The extent to which this factor of contemporaneous breeding prevails among the organisms of fresh waters and the full force of its bearing upon the problem of isolation are best understood when the fact is borne in mind that the whole ensemble of organisms constituting the plankton, runs throughout the year, year in and year out, this rhythmical series of recurrent cycles. In this most, if not all, of the constituent plants and animals have coincident periods of rapid increase followed by one of subsequent declines offering, in cases of sexual reproduction, repeated opportunities for the interbreeding of related forms, and the swamping out of incipient species arising by the slow accumulation of minute fluctuating variations. There appears, however, to be no lack of specific differentiation among these organisms. Isolation by external factors seems to play a small part, if indeed any, in specific differentiation in this type of habitat.

The pelagic life of the sea abounds in seeming instances of the coincident distribution of closely related species in an environment presenting a minimum degree of diversification and a relative absence of barriers. The incompleteness of our knowledge of the horizontal and vertical distribution of pelagic organisms and of their breeding seasons leaves here much to be desired in the data for a discussion of this problem. There is great specific differentiation among pelagic diatoms, Radiolaria, Foraminifera, Dinoflagellata, Copepoda and Amphipoda. Frequently many species of the same genus occur in the same region, witness the fifty species of *Coscinodiscus* found by Karsten in the Antarctic plankton of the Valdivia Expedition, largely at a depth between 60 and 40 meters.

The genus *Ceratium* of the dinoflagellates is one of the most diversified and its species are among the most variable of marine organisms and are mainly of wide distribution. In the plankton of the Pacific immediately at the surface, that is in the upper 2–3 meters, it is no unusual thing to take 25–30 species in a single 14-inch net.

There are three species of *Ceratium* which are usually coincidently abundant in the Pacific off San Diego which are most closely related, so closely in fact that their distinctness has frequently been overlooked by casual

workers on this genus. They are the cosmopolitan *C. furca* (Ehrbg.), and *C. lineatum* (Ehrbg.), and the minute *C. eugrammum* (Ehrbg.). The species are evidently closely related, differing only in certain proportions of the midbody, in the degree of ventral excavation and in size. The examination of a wide range of material and a statistical study of their proportions has convinced me of their distinctness. Their resemblances are so plainly marked that one is forced to conclude that they are branches of a common stem or co-mutants. *C. furca* and *C. lineatum* are widely distributed in temperate and tropical seas and the occurrence of *C. eugrammum* in both the Mediterranean and in the Pacific is suggestive of a similar range. Its small size enables it to slip through the mesh of even a fine plankton net. This fact, together with its resemblance to *C. lineatum*, doubtless explains its comparative absence in published records of distribution. These species are abundant at the same seasons, and are taken repeatedly at the same levels in the same net. Their pelagic habit is suggestive of a pelagic origin and their coincident distribution over wide areas would seem to afford abundant and oft-repeated opportunities for swamping out incipient species by interbreeding of the diverging forms with parental stock, provided their origin took place by the gradual accumulation of minute fluctuating variations.

The lists of plankton organisms in European seas published by the Conseil permanent pour l'exploration de la mer, as well as our records for the past four years at San Diego, show many instances of the coincident distribution of *Ceratium macroceros, C. longipes,* and *C. intermedium,* three closely related species, all having open tips to the antapical horns and more or less postindentation, but differing from each other in size, form of the shoulders and the angular divergence of the horns. These species are so closely related that they have been much confused in the past, but our best specialists in this group are now agreed that the species are distinct. They are the most closely related species of their section of the genus to which they belong and they have a coincident and apparently coextensive distribution in temperate seas.

Another striking instance of coincident distribution is found in the species of the *C. tripos* group, including the closely related *C. azoricum, C. arcuata, C. heterocamptum, C. bucephalum* and *C. curvicorne,* which are very often found together in the plankton of the Pacific and extensively throughout much of the Atlantic as Cleve has shown in his 'Seasonal Distribution of Atlantic Plankton Organisms.'

Dividing twenty-seven of the more common species of *Ceratium* in groups of most closely related species and determining their distribution in surface waters of the Pacific in twenty-one typical collections, we find that the percentage of coincident distribution of the species of the several groups actually realized in the collections ranges from 48 per cent. to 68 per cent. on an average.

Unfortunately for my discussion, we know neither the strata nor the seasons in which the sexual reproduction of these organisms occurs, if, indeed, any exists.

It will doubtless be suggested by defenders of the universal potency of isolation in the origin of species that the instances of coincident distribution of related species which I have here cited are those of organisms which multiply predominantly by asexual methods or at least by parthenogenesis, that sexual reproduction is entirely, or at least relatively, absent and that this in itself constitutes an effective isolation and prevents the swamping out of new forms. In reply to this attention should be directed to the admirable researches of Dr. Schaudinn and of Professor Richard Hertwig, and especially to the results of investigations into the life histories of the *Sporozoa* and the *Foraminifera* which have brought to light the wide-spread occurrence of typical sexual reproduction in so many of the protozoa. So striking have been these results that it is safe to say that a full knowledge of life histories will reveal sexual reproduction in all protozoa. Over against the apparent infrequency of sexual reproduction in the protozoa and many fresh-water organisms should be placed the brevity of the life cycle and the considerable

number of sexually produced generations which are possible every year. *Polyarthra platyptera,* a common cosmopolitan rotifer, produces, in the Illinois River, male and winter eggs throughout most of the year at the close of parthenogenetic cycles of 3–6 weeks duration. It is not improbable that other organisms of the same habitat run a similar course and exhibit a corresponding proportion of sexual reproductions. Opportunities for swamping out incipient species are present, therefore, in these organisms, at least in so far as the existence of sexual reproduction offers them, in limnetic and pelagic organisms as well as in the fauna and flora of the land or in animals of higher organization. The work of Maupas and Calkins on the recurrence of conjugation in ciliates is significant as indicating the necessity of sexual reproduction among unicellular organisms.

Evidence of the coincident distribution of related species of higher pelagic organisms in which amphigony is the only form of reproduction may be found among the chætognaths. Other groups of pelagic organisms should be examined on this point. The publication of Fowler's excellent monograph on the chætognaths in the reports of the "Siboga" expedition, in which he reviews the matter of their distribution, affords some pertinent data of prime significance because the group is a sharply circumscribed one with but few species, the distribution of most of which is fairly well known. There are but three genera, *Sagitta, Krohnia* and *Spadella* in which the author recognizes twenty, three and two species, respectively. The two species of *Spadella* are members of the epiplankton and their areas of distribution overlap. In the case of *Sagitta* there are twelve species which belong to the epiplankton of warm temperate and tropical waters. In this group are both cosmopolitan and apparently restricted species. The remaining eight species belong to colder or deeper waters (5) or are of undetermined range (3). Of the twelve species at least ten are known to occur in the Indo-Australian or Indo-Pacific regions, where they exhibit coincident or overlapping distribution.

The species of *Sagitta,* though relatively few in number, are often so similar in structure as to be separated with great difficulty even by a specialist. One of the most closely related groups in the genus is that formed by *S. serratodentata,* a cosmopolitan eurythermal species ranging in the epiplankton from the latitude of the Straits of Magellan to the equator, and by *S. bedoti, S. ferox* and *S. robusta* from the epiplankton of the Indo-Pacific region. These four species occur together *repeatedly* in the Siboga collections of surface plankton. A second group of related species is formed by *S. enflata, S. hexaptera* and *S. pulchra* which likewise occur together in the same collections often in large numbers. The first two species of this section are ones of wide range and the last an Indo-Austral one.

S. neglecta and *S. regularis,* two closely related neritic species from the Malay Archipelago, form a third group having a coincident distribution. There are possibly two instances, *S. furcata* and *S. planctonis,* and *S. bedoti* and *S. sibogæ,* where related species have a contiguous distribution in epiplankton and mesoplankton. The data are too scanty for definite conclusion.

It appears from Fowler's records that, as a rule, the *most closely related* species of this genus have, not a *contiguous,* but a *coincident* distribution. In the present condition of our knowledge it is impossible to state whether these species breed at the same seasons or not. Shipley in the Cambridge Natural History states that *Sagitta* breeds throughout the year. Fertilization is presumably external in many species, though known to be internal in one and eggs are pelagic, but there are no geographical barriers which intervene to prevent the swamping out of incipient species. Provided there are in these related species of *Sagitta,* no differential breeding seasons, and no differential levels or temperatures at which extrusion of ova and sperm occur, no assortive assemblings of the individuals of the given species during specialized breeding seasons and no close fertilization, we are compelled to fall back upon the assumption of a sterility of the cross between an incipient species and

its parent stock or preferential mating of like forms for an explanation for the origin and continuance of these closely related species in a coincident environment. This is the solution which Darwin proposed to meet this difficulty. De Vries finds that the *coincidently* appearing new elementary species of *Œnothera* attain their full constancy at once. Isolation plays no part in their origin or continuance.

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University of California

Note on a Tertiary Basin in Northern Alaska[1]

Beds of Tertiary age are known in various widely separated regions of Arctic and sub-Arctic America. They occur generally in basins of limited area in the older rocks. Such basins are rather widely distributed in Alaska. Brooks[2] has recently reviewed the literature relating to those in Alaska. A number of isolated Tertiary basins are known in the islands of the Arctic Archipelago[3] and others have been reported in the Northwest Territory[4] east of northern Alaska. The age of nearly all of the Tertiary beds which are known in Arctic America has been determined from plant remains occurring in them, so that we have a very fair knowledge of the plant life of northern America in Tertiary times, but a very meager knowledge of the invertebrate fresh-water fauna which lived in some of the Tertiary lakes of Arctic America. The discovery of such a fauna by the writer during the past summer along the Porcupine River in northeastern Alaska seems, therefore, worthy of record.

About one hundred miles above its junction with the Yukon the Porcupine River enters the Yukon Flats, an alluvial plain without topographic relief, through which the Yukon River flows for 200 miles. Before entering the Yukon Flats the Porcupine traverses for about 25 miles a belt of limestones of Paleozoic age having a north and south trend and giving rise to low mountains and hills. Between this belt of elevated country and a similar but wider zone of topographic relief near the international boundary extends a comparatively flat basin having a width of about 25 miles. The north and south extent of this basin, which Maddren has called the Coleen Basin,[5] after the river draining its northern portion, is unknown. There is good reason to believe, however, that its north and south extent is much greater than its width. The Porcupine traverses this basin in wide sweeping meanders. The migration of the channel of the river along parts of its course through this basin has left in places low banks bordered by recent silts. An older set of sediments, however, constitutes the bulk of the floor of the Coleen Basin. These older sediments are well exposed on the largest meander in this portion of the river, known as the Fish Hook bend, which shows continuous bluffs for two or three miles, 40 to 100 feet high, composed mainly of finely laminated shale or clay. The dominant color of these beds is light lemon yellow, which is varied by patches of yellowish green, pink, and brownish. At the upper end of Fish Hook bend, on the west bank of the river, the following section was measured:

	Feet.
1. Fine sand, soil and muck (top)	1– 5
2. Coarse gravel and sand	10
3. Dark carbonaceous clay and old forest bed	0– 2
4. Coarse gravel and sand	15
5. Soft, finely laminated, drab-colored clay shale, with large ironstone concretions in upper part, containing fresh-water bivalves	70

The fossils which were secured from the ferruginous concretions occurring in divi-

[1] Published by permission of the Director of the U. S. Geological Survey.

[2] 'The Geography and Geology of Alaska,' professional paper U. S. Geological Survey, No. 45, pp. 237–244, 1906.

[3] Low, A. P., 'Cruise of the Neptune,' 1906, pp. 226–229.

[4] McConnell, R. G., 'Report on an Exploration in the Yukon and Mackenzie Basins, Northwest Territory,' Can. Geol. Surv., Vol. 4, n. ser., Rept. D, 1890.

Camsell, C., Report on the Peel River and Tributaries Yukon and Mackenzie, Can. Geol. Surv., Vol. XVI., 1906, Pt. C, pp. 27–28.

[5] 'Smithsonian Exploration in Alaska in 1904 in Search of Mammoth and other Fossil Remains,' *Smithsonian Misc. Coll.*, Vol. 49, 1905, p. 12.

sion 5 of the section were referred to Dr. W. H. Dall, who reports that "One resembles *Unio onariotes* Mayer from the Kenai formation, another *Anadonta athlios* Mayer of the same beds, but they are probably not identical. The beds are probably Oligocene or upper Eocene, like those of Kenai." Considerable interest attaches to these fossils in connection with their bearing on the distribution in Tertiary times of the Naiades, a group represented in the present streams and lakes of lower latitudes in North America by several hundred species.

Maddern[6] and McConnell[7] have reported two basins similar to the Coleen, but larger, higher up the Porcupine a short distance east of the international boundary. One of these has an approximate length of 100 miles and a width of 60 miles. No fossils were obtained by McConnell from these upper basins, but the description which he gives of the beds exposed, corresponds so closely to the sections observed by the writer, that it is highly probable that the age of the beds in the basins on the two sides of the boundary is the same. McConnell[8] expressed a similar opinion concerning the equivalence of the beds in question, but presented no paleontologic evidence of the age of the beds in either of the basins which he described.

E. M. KINDLE

U. S. GEOLOGICAL SURVEY,
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QUOTATIONS

THE UNIVERSITY OF MAINE

THE movement to remand the State University of Maine to its original purpose of an agricultural college and school of mechanic arts has failed. The University has expanded with a college of liberal arts and has been giving the bachelor's degree, and this the senior colleges of liberal arts in the State, Bowdoin, Bates and Colby, consider to be crowding an already overstocked market for higher education. Consequently, when the University came to the Legislature this year for an appropriation equal to two fifths of a mill to the valuation of the State, or about $150,000 a year, with a backing of the majority report of a committee appointed by the last Legislature, and then accepted as a substitute for this an appropriation of $65,000 a year for two years and $90,000 for new buildings, the three colleges appealing to the committee of the Legislature on the subject, united under the leadership of President Hyde, had attached to the appropriation as a condition the discontinuance of the University's courses leading to the B. A. degree. In the House this amendment to the appropriation was defeated by the cyclonic vote of 123 to 12. In the Senate, however (which had made a special investigation with a recess committee of the whole subject), the vote was much closer, being, in fact, only 17 to 13 in favor of the University's retention of the right to confer the B. A. degree * * * .

In the heat of the debate the dignity of the university and the quality of its scholarship have been sometimes rather roughly used. The statement made by President Hyde and repeated by ex-Senator Potter of Brunswick, an overseer of Bowdoin, that the liberal arts courses at the University of Maine are inferior to those of the other three colleges is pretty well disposed of by the statistical facts that there are eleven professors at the university holding doctor's degrees conferred by the highest institutions of learning at home and abroad, including Harvard, Johns Hopkins and Cornell in this country and Berlin and Heidelberg universities, a total greater than is found in the faculties of the other three colleges together. Mr. Carnegie, it is believed for the first time, gave the university last year the money for a library building absolutely without conditions, and by energy, thrift and the use of local materials, almost given to the university, a building has been erected for his $55,000 equal in appearance, it is said, to one costing twice as much. Evidently this sturdy young growth from the Federal land grant known as the Morrill education fund is past all danger of being up-

[6] *Smithsonian Misc. Coll.*, Vol. 49, 1905, p. 14.
[7] Ann. Rept. Geol. Nat. Hist. Surv. Canada, n. ser., Vol. 4, 1890, p. 128.
[8] *Ibid.*, pp. 128, 132.

rooted, and now needs only to be judiciously tended and watered.—*Boston Evening Transcript.*

CURRENT NOTES ON LAND FORMS

DRAINAGE CHANGES IN CALIFORNIA

J. C. Branner describes 'A Drainage Peculiarity of the Santa Clara Valley [Cal.] affecting Fresh-water Faunas' (*Journ. Geol.*, XV., 1907, 1–10), in essence as follows: A stream flows westward from the Mt. Hamilton group into the middle of the longitudinal (N.W.–S.E.) Santa Clara Valley of the Coast range, and there builds up a great alluvial fan which forms a divide on the valley floor. The stream at present flows northwest from the fan by Coyote Creek to the southern end of the Bay of San Francisco. Another creek heads in the longitudinal valley near the fan and flows southeast to join Pajaro River, which runs westward into the Bay of Monterey. A slight radial shifting of the stream on the fan would transfer it to the Pajaro system. There is good evidence that such shifting has occurred in the past, probably repeatedly, so that the waters from Mt. Hamilton have found their way alternately into the two bays. Such stream changes would permit a mingling of the faunas of the Coyote and Pajaro basins. Should a long time then elapse without further changes in drainage, the unified faunas might spontaneously and gradually diverge. At present the fishes of the two rivers are remarkably alike in most respects; some points of difference are taken to indicate the beginning of spontaneous divergence.

It appears, however, that the faunal peculiarities common to these two rivers are noted also in other rivers flowing into the two bays. As the mouths of the rivers are now separated by salt water and as their heads are far apart, a second hypothesis must be advanced to account for the community of forms, which Branner believes to require direct fresh-water connection at some former time. A former elevation of the coast, permitting the rivers of each bay to unite in a main river system, is believed to afford a satisfactory explanation for the phenomena observed. Each of the two main river systems would then have had its own fauna, until changes on the alluvial fan, as above described, had mingled them in a single fauna common to both basins. Submergence would then dismember or betrunk the two systems, yet the isolated rivers would still have similar faunas.

Independent evidence is given of the elevation and submergence here postulated. The amount of elevation is believed to have been great. In view of this it would be interesting to know whether the possibility has been considered that, during such uplift, the two main river systems might have united in one, permitting a mingling of faunas independent of the stream changes on the fan at the divide.

D. W. J.

THE PENEPLAIN OF BRITTANY

E. de Martonne, lately professor of geography in the University of Rennes and now in that of Lyons, gives an effective description of the peninsula of Brittany, illustrated with expressive block diagrams and photoplates ('La pénéplaine et les côtes bretonnes,' *Ann. de Géogr.*, XV., 1906, 213–236, 299–328). Brittany is a district of greatly deformed ancient rocks, worn down for the most part to a peneplain, but retaining here and there certain residual reliefs of moderate altitude; the whole gently up-warped in Tertiary time, and now more or less dissected in a second cycle of erosion. The chief residual reliefs or linear monadnocks follow the east-west structural trend somewhat north of the middle of the peninsula. In spite of their moderate altitude (250 meters), they are sparsely inhabited; some of the peasants there are still ignorant of the French language and speak only Breton. The peneplain, admirably developed and preserved north of the residual hills, is sharply dissected by young valleys towards the bold coast; but when the valleys are followed southward towards their heads they open out on the upland. The peneplain on the southern side of the peninsula is more destroyed by revived erosion, because larger areas are here occupied by relatively weak rocks, some of which have been almost re-

duced to local peneplains of a second generation. The southern coast is less bold than the northern, because the peneplain slopes gently southward under the sea. A recent gain of the sea on the land has drowned the distal parts of all the streams, and carried vigorous tidal currents into the incised meandering valleys. Along the southern part of the shore line thus determined, the sea has already formed numerous smooth-beached sand reefs; but little advance to such maturity is seen on the ragged western promontories and bold northern coast, where marine action is still chiefly destructive.

It is gratifying to see so systematic a treatment of a physiographic province on the basis of structure of rock masses, process of sculpture and stage of development, stated in the compact terms of the cycle of erosion and illustrated with typical block diagrams which combine structure and form in so simple and suggestive a manner. It is at the same time indicative of the stage of physiographic development of the readers of the *Annales de Géographie*—the most scholarly geographical periodical in France—to note that the transformation of valleys into arms of the sea by drowning is here presented in a more or less argumentative manner, as if it still needed discussion and demonstration before it could gain acceptance. It is also significant that Brittany is here described as having an Appalachian structure and development, as if this new world example of a corrugated structure, peneplained, elevated and redissected, were so well established that it served as a type for the description of a somewhat similar example in the old world.

There are two points on which supplement may be made to de Martonne's very readable article. First, that although the sea works furiously, with heavy storms and strong tidal currents, on the western and northern coast, the outer shore line there is still in a young stage of development, marked by an increase of irregularity and raggedness over that of the initial shore line; hence a recent date must be given to the depression by which the valleys were drowned and the initial shore line of the present cycle was formed. Second, when the recent depression of the region occurred, it presumably caused the submergence of an extensive lowland, worn down on a large area of weak rocks north of Brittany in the second cycle of erosion. Submergence thus formed the western part of the English channel, and brought the sea against the northern marginal slope of the hard-rock upland of the earlier peneplain, a little outside of the present cliff line. When explained in this way, the northern cliffs of the peninsula do not, in spite of their height, indicate a great consumption of the land by the sea, as has been supposed by some authors.

W. M. D.

PHYSIOGRAPHIC TYPES

THE address delivered by the late Professor Israel C. Russell on 'Physiographic Problems of To-day' at the Congress of Arts and Science, Universal Exposition, St. Louis, in 1904, is brought again to mind by its recent publication in the proceedings of the Congress (Vol. IV., Boston, Houghton, Mifflin & Co., 1906, 627–649). One of its most suggestive passages is concerned with 'ideal physiographic types,' by which the author meant "complete synthetic examples of * * * physiographic forms, which will serve the rôle of well-defined species in the study of the surface features of the earth. Ideal types may be likened to composite photographs. They should combine critical studies of many actual forms, within a chosen range, and in addition be ideally perfect representations of the results reached by specific agencies operating under the most favorable conditions. * * * A well-arranged catalogue of ideal types would be an analytical table of contents to the history of the evolution of the features of the earth's surface, and constitute a scheme of physiographic classification. * * * The selection of idealized physiographic types * * * has for its chief purpose the reduction of endless complexities and intergradations to practicable limits. It is a method of artificial selection so governed that, while no line in the chain of evolution may be lost to view, certain links are chosen to represent their nearest of

kind and serve as types." When this suggestion is well carried into practise, geography will have made a great advance.

W. M. D.

SYSTEMATIC PHYSIOGRAPHY

A SERVICEABLE article by Hettner, professor of geography at Heidelberg, on 'Das Wesen und die Methode der Geographie' (*Geogr. Zft.*, XI., 1905, 545–564, 615–629, 671–686), revives Ritter's conception of geography as the science that is concerned with the material filling of terrestrial spaces—'die dingliche Erfüllung der Erdräume'—and emphasizes the importance of the causal notion which has been coming into greater and greater prominence in the last half century, as fuller explanation has been found for the earth's physical features, and as fuller meaning has been given to the distribution and behavior of plants, animals and man by the philosophy of evolution. He recognizes also the advantage that comes from a scientific terminology in making short and clear descriptions possible; yet he expresses a doubt as to the possibility of describing various geographical features such as valleys and towns, in generic terms, because such features possess so many details which can be portrayed only by individual description. The Neckar Valley is taken as an example to illustrate this conclusion; it is briefly described as 'a *Durchbruchstal* formed in a climate without the cooperation of ice action; we can perhaps still find even a few more generic features, but everything else is individual.' This is hardly more than begging the question, for the possibility of giving an adequate account of the Neckar Valley in terms of generic features can not be so lightly tested. The study of the development of generic features in the class of incised meandering valleys, to which the Neckar Valley belongs, has already proved the repeated or systematic occurrence of various minor elements whose recognition greatly increases the power of description. (See an article by the undersigned on 'Incised Meandering Valleys,' *Bull. Geogr. Soc. Phila.*, July, 1906.) In view of the notable progress of this kind in recent years there is every reason to expect a still greater progress in the years to come: there is indeed no direction in which a physiographer may labor more profitably than in contributing to this progress. Instead of practically giving up the problem, and abandoning the method of systematic or generic description of geographical features as impracticable because insufficient, as Hettner suggests, it is our plain duty to make every effort to develop it farther than its present stage, in the manner suggested by Russell in the preceding note; and there is good ground for hope that systematic description may yet be so far advanced, especially if carefully chosen adjectives are consistently used to modify the generic nouns which represent standardized type forms, that whatever local supplement is needed will be not so well given by an unsystematic verbal account of individual features as by reference to a good map, where many items that are fatiguingly represented in words are very easily shown graphically.

W. M. D.

THE NEW GEOLOGICAL SURVEY OF BRAZIL

The Diario Official, the official organ of the federal government of Brazil published at Rio de Janeiro, in its issue of January 22, 1907, prints the text of the decree establishing the Brazilian Geological Survey or, as it is called officially, the 'Serviço Geologico e Mineralogico do Brazil' (the geological and mineralogical service of Brazil). This decree was approved January 10, 1907, by the president of the republic, Affonso Augusto Moreira Penna, and by the minister of industry and public works, Miguel Calmon du Pin e Almeida, and has already gone into effect.

The following instructions are translated from the same issue of the *Diario Official:*

Instructions for the Operations of the Serviço Geologico e Mineralogico do Brazil

Article I.—The following are the principal objects of the geological service:

1. To carry on a scientific study of the geological structure, mineralogy and mineral resources of the territory of the republic, having

especially in view the development of the mineral resources and of the surface and underground waters and the collection of such information regarding the geologic and physiographic nature of the country as may serve as a basis for the determination of routes of communication and other public enterprises, especially such as may tend to relieve the effects of drouths.

2. To maintain a laboratory and museum of geology and mineralogy and to collect, classify and arrange for exposition in this country and in the chief foreign centers specimens accompanied by proper information suitable to give those who may be interested as complete knowledge as possible concerning the geology, mineralogy and mineral resources of Brazil; and to have made such chemical, paleontological and other investigations as may tend to the fulfillment of the principal objects of the service.

3. To prepare and publish maps, plans, diagrams and drawings or photographs for the illustration and elucidation of the investigations, reports and other publications of the service.

4. To organize and publish statistics of the mineral production and of the mining and metallurgical industry of the country; to study facts relating to water-supply both for irrigation and for domestic and industrial purposes; to study the question of artesian and other wells, and also matters relating to the mines and mining enterprises in the country and systematically to make known its mineral wealth.

5. To furnish data and information upon questions relating to lands and mines and also upon all questions concerning the mining industry and other objects of the service whenever called upon by the federal government, or, with the government's authorization, when called upon by the state governments or by private parties.

Article II.—The appointment of the technical and administrative assistants of the service, with the exception of the chief, will be made by the minister.

The chief of the geological and mineralogical service will be appointed by decree.

Article III.—It shall be the duty of the chief of the service:

1. To appoint and dismiss such assistants as are not subject to appointment by the minister, to indicate their salaries and to fix the wages of technical assistants.

2. To organize, direct and fiscalize the work of the service and to assign the duties of the assistants.

3. To call upon the proper authorities either personally or through his representatives for whatever may be necessary in the prosecution of the work.

4. To furnish, whenever required to the ministry, information regarding expenses incurred and results accomplished, and to make an annual detailed report regarding the affairs of the service.

5. To make provisions in urgent cases for any omissions in the present instructions, and subsequently to submit his act for the approval of the government; also to indicate who shall act in his stead in cases of impediment.

Article IV.—The technical personnel composed of specialists of recognized fitness shall carry on the studies and work of the service in accordance with the expressed instructions of the chief.

Article V.—The secretary together with the clerk shall do the writing and keep the accounts of the service and of such other work relating to it as the chief may direct.

Articles VI., VII. and VIII. relate to expenses and the salaries, while article IX. provides for the further development of the service.

Under this decree Professor Orville A. Derby was appointed chief of the service, and the chief has asked for the appointment as assistants of the following Brazilian geologists:

Dr. Miguel Arrojado R. Lisboa, to have charge of the investigation of the gold, iron and manganese deposits in the state of Minas.

Dr. Luiz Filippe Gonzaga de Campos, who will probably undertake geological studies on the Rio Purus in the Estado do Amazonas.

Dr. Francisco de Paula Oliveira will proceed with his studies of the coal deposits of Santa Catharina and Rio Grande do Sul.

Professor O. A. Derby, the chief of the service, is a native of the state of New York, having been born at Kelloggsville in 1851. He entered Cornell University in 1869, graduated in 1873, and took his master's degree in 1874. He accompanied Professor Hartt to Brazil in 1870, 1871 and again in 1872. In 1874 Professor Hartt went to Brazil, leaving Mr. Derby as assistant in charge of the department of geology at Cornell. A geological survey of Brazil (Commissão Geologica do Brazil) was inaugurated in 1875 with Professor Hartt as chief, and on this Mr. Derby was appointed assistant geologist. He reached Rio de Janeiro in 1875, and he has lived in Brazil ever since. He was connected with the geological commission as long as it lasted; upon its suspension and after the death of Professor Hartt he was appointed director of the geological section of the national museum in Rio de Janeiro. In 1886 he was made director of the geological and geographical survey of the state of São Paulo, a position which he retained until 1905, when he resigned.

Among the authorities upon Brazilian geology Professor Derby is *facile princeps*. His papers on the subject number something over one hundred, and other writers upon Brazilian geology have also drawn largely upon his rich store of information. In addition to his own direct contributions he has been instrumental in getting the cooperation of many of the best specialists in the world to work up and describe special collections. For example, the 'Cretaceous Paleontology' of Brazil by Dr. C. A. White and the 'Paleozoic Faunas of Pará' by Dr. John M. Clarke are monumental contributions to the geology of Brazil that were made possible by Mr. Derby's efforts and cooperation. The well-known writings upon Brazilian mineralogy and petrography by Dr. E. Hussak were also made possible by Professor Derby's appointment of that able geologist to a position on the São Paulo survey. Among Mr. Derby's most noteworthy direct contributions to geological literature are his papers on the origin of diamonds, on the nephelene rocks of Brazil, and on the geology of the lower Amazonas.

Dr. Gonzaga de Campos is a native of the state of Maranhão, where he was born in 1857. After completing the preparatory course in the Polytechnic School of Rio de Janeiro, he entered the newly established School of Mines at Ouro Preto as one of its first students, graduating with honors in 1880. He did private work for a year, when he was called as assistant to the geological Survey of the state of São Paulo, then being carried on under the direction of Professor Derby. He has published ten important papers upon Brazilian geology. Of these papers, one upon the coal deposits of Santa Catharina, another upon the diamond deposits of Agua Suja of Minas, and a third upon the bituminous shales of Marahú in Bahia are especially worthy of mention.

Dr. Miguel Arrojado R. Lisboa is a native of the city of Rio de Janeiro, where he was born in 1872. He is the grandson of the Baron of Japurú, who was some time Brazilian minister at Washington. His technical training was received at the School of Mines at Ouro Preto, where he graduated in 1894. After graduation he was employed as geologist by Barão de Capanema and later he entered the topographic corps engaged in mapping the state of Rio de Janeiro. From 1898 to 1900 he studied at the University of Berlin and in Paris and, returning to Brazil, opened an office as mining engineer and consulting geologist in Rio de Janeiro. Dr. Lisboa is the author of about a dozen papers upon the geology and mining industries of Brazil. The most important of these are upon the Brazilian manganese deposits, the monazite sands, and the iron industry of Brazil. The January, 1907, number of the *American Journal of Science* contains an article by Dr. Lisboa upon facetted pebbles found by him in the interior of Brazil.

The other assistant, Dr. Francisco de Paula Oliveira, is also a native Brazilian, and a graduate of the School of Mines at Ouro Preto. He is an active and prolific writer, being the author of seventeen papers upon the

geology and mineralogy of Brazil. It is expected that additional assistants will be appointed in the near future.

The Brazilian people are to be congratulated upon the establishment of this important service. The development of the great mineral resources of that country and the growth of a healthy, hopeful and helpful interest in geology may now be looked for with confidence.

The character, the professional high standing and the unselfish patriotism of the men entrusted with the survey are a guarantee of the abundant and trustworthy results to be expected.

J. C. BRANNER
STANFORD UNIVERSITY, CALIFORNIA,
March 7, 1907

THE FAYÛM EXPEDITION OF THE AMERICAN MUSEUM

IN the Middle and Upper Eocene fluviomarine formation of Northern Egypt most important paleontological discoveries were made between 1902 and 1905 by Mr. Beadnell, of the Egyptian Geological Survey, and Mr. C. W. Andrews, of the British Museum of Natural History. From being the terra incognita of paleontology Northern Africa suddenly sprang into prominence as the center of origin and evolution during the Eocene and Oligocene periods of four great groups of mammalia whose early history had previously been entirely unknown. These were, in order of importance, the Proboscidia or mastodons and elephants, the Sirenia or manatees and dugongs, the Hyracoidea or tree and rock conies and the Zeuglodontia or Archæoceti, or primitive toothed whales. Together with the primitive, or rather the early forms of these mammals, because certain of them are already highly specialized, occur a few members of two other faunæ, namely, of the upper Eocene of France, and secondly a purely African contingent including chiefly the giant horned quadruped appropriately named *Arsinoïtherium*. This animal held an adaptive position in the faunæ complex somewhat similar to that of *Dinoceras* in our western tertiaries. Large collections of these mammals were made by the Egyptian Survey for the Cairo Museum and by the British Museum, on which was based the admirable memoir by Dr. C. W. Andrews published by the British Museum some months ago.

This fauna has a peculiar interest for the department of vertebrate paleontology in the American Museum because three of these great African or Ethiopian groups of mammals sooner or later reached North America, namely, the Zeuglodontia in the Eocene of Alabama and Georgia, the Sirenia in the Miocene of the western coast, the Proboscidea in the Middle Miocene of the western tertiaries. The subsequent American phases are all represented in the museum collections, and it was obviously desirable to trace the ancestry back to the earliest known stages. A further cause of personal interest to Professor Osborn was the fact that in an address before the New York Academy of Sciences in 1900 he had predicted that three or more of these groups would most probably be discovered in Africa. The publication of Andrews's memoir made the field and the subject free for scientific research by other workers and after considerable correspondence and inquiry into the probabilities of success the project of an expedition was approved by the president and by the director of the American Museum. With his usual liberality President Morris K. Jesup decided to defray the chief expenses of a three or four months' expedition, and preparations were made to leave New York on January 5 and to begin work in the Fayûm as early as possible in order to take advantage of the cool months of the Egyptian winter. Professor Osborn selected as his assistants Mr. Walter Granger and Mr. George Olsen, of the museum staff. President Roosevelt, Mr. Joseph H. Choate and Director Charles D. Walcott sent letters to Lord Cromer and other officials of the English protectorate supporting the chief objects of the expedition.

The party reached Cairo on January 24, expecting to occupy ten days or more in outfitting with camels, water tanks, supplies and men. But Director H. G. Lyons, of the Egyptian Geological Survey, entirely altered this estimate by most liberally placing all the necessary equipment from the survey at Pro-

fessor Osborn's disposal and further facilitating the work of preparation in every possible manner. Captain Lyons cooperated still further by detailing Mr. Hartley T. Ferrar, formerly geologist of the British Antarctic Expedition, to accompany the party. Mr. Ferrar's experience in dealing with the natives subsequently proved to be of great service. Natives who had been out with Messrs. Beadnell and Andrews were engaged. The heavy equipment was sent round by rail to Tamia, on the northern edge of the Fayûm oasis, there to be transported by caravan two days' journey, or thirty miles, to the nearest of the bone-bearing localities. It thus came about that exactly one week from the time of arrival in Cairo the expedition started by caravan from the Gizeh pyramids a few miles west of Cairo.

On the journey south the caravan followed the line of the pyramids of Gizeh, Abusir, Sakkara, Deshûr and Lisht. This gave an opportunity of observing the methods of excavation on a large scale by native labor. At Gizeh Dr. Reissner is excavating for the Boston Museum of Fine Arts, with a very large force of men and boys, and at Lisht Dr. Lythgow, another American, is just beginning his explorations for the Metropolitan Museum of Art. The natives are believed to be direct descendants of the builders of the pyramids of five thousand years ago and the tools and carrying baskets have remained unchanged. Wages have risen rapidly in recent years and boys now receive from two to three piasters a day, while the skilled men receive five piasters, or twenty-five cents. At Sakkara are the workings of the Egyptian Museum under Dr. J. E. Quibell. The meeting here proved to be a most fortunate one because Dr. Quibell placed at the disposal of the American Museum party twelve of his best workmen, who were engaged at once to proceed to the bone beds.

The bone beds lie exactly forty miles in a southwest direction from Cairo. The route taken by the party, following the southward line of the pyramids and then turning due west, covered seventy miles, or twenty-eight hours' caravan. A freighted caravan moves so precisely at the rate of 2½ miles, or 4 kilometers, an hour that all desert distances in Egypt are estimated in caravan hours. On the evening of February 5, one month from the date of departure from New York, the party reached the most easterly 'bone pits' as indicated on Mr. H. E. Beadnell's admirable survey map of the Fayûm district. Some of the Egyptians had arrived two days before and had already begun excavation. Two days later the Sakkara force of natives arrived and the camp presented the most picturesque and imposing aspect. Stretched out on the gradually shelving bench of upper Eocene sand were eleven tents. Twenty-six camels were traveling to and fro on the three days' distant water supply. Their groans filled the early morning air.

The topography is extremely interesting. The Fayûm is a very ancient, perhaps late Pliocene, depression, lying closely contiguous to the Nile, which in Pleistocene times converted the basin into a great lake substantially similar in outline to the Lake Moeris of the Ptolemies. Control of the inflow and reclamation of the alluvial bottom began under the ancient Egyptians until now the shallow and brackish Birket el Kurun (Lake of the Horns) stretches 41 meters below sea level and 15 miles east and west as the last and ever-diminishing vestige of the ancient lake. It is fed by the waste of the irrigation waters. The easterly end of this lake is twenty-six miles west of the Nile. Rising from the north shore of the lake and overlooking it like the tiers of an amphitheater are the benches of Middle and Upper Eocene age, the lower steps purely marine, the upper littoral and fluviatile, which finally rise tier above tier, 341 meters, to the summit platform of the Libyan desert. In a gentle northeasterly and southwesterly direction these benches extend for a distance of 45 surveyed miles, beyond which the Eocene is unsurveyed. This noble section has long attracted the attention of German geologists and the fossils of its lower marine members, as studied by Schweinfurth, Blanckenhorn and Zittel, afford proof of a close synchronism with the Middle and Upper Eocene of the Paris Basin. In the southwest is the famous 'Zeuglodon Valley' full of the skeletons of

these ancient and aberrant whales. These animals as well as the Sirenians from the lower members of this great formation have been known since 1879. In 1898–1901 Messrs. Beadnell and Andrews discovered a number of land mammals in these marine or littoral beds, and in the latter years a turning point in the history of paleontology was reached by the discovery of *Palæomastodon* teeth in the upper fluviatile beds. The working of this level between 1901 and 1904 by the Cairo and British Museum parties, and less thoroughly by collectors for other museums, has been principally on a bench 160 meters above sea-level, about 40 meters in thickness, and with a fossiliferous exposure of not over ten miles east and west. Evidence of very thorough prospecting and of excavation on a large scale is everywhere apparent. The bone-bearing stratum is evidently of fluviatile origin, consisting of cross-bedded and often brightly colored sands, sometimes intermingled with clay concretions. All can be worked with a light pick and shovel or with the broad-edged mattox which the natives prefer. Bones are often found broken, more seldom entire; they occur in pockets from 30 to 100 feet in diameter. Several of these pockets or 'bone pits' are reserved by the Egyptian survey but the privilege to work them further was kindly extended by Director Lyons to the American Museum. The conditions of deposition are altogether unlike anything in the American Western Eocene, but resemble as closely as possible the Lower Pleistocene, Sheridan or Equus Beds of our west.

While Professor Osborn and Mr. Ferrar were engaged in a survey of the whole region, simultaneous excavation of two of these 'bone pits' was begun at once under the direction of Mr. Walter Granger and Mr. George Olsen, of the museum party. It soon became apparent that the six workmen from the Helouan stone quarries who had previously been out for the Cairo and British Museums were too impatient to find large bones and too careless with delicate objects, whereas the twelve workmen from Sakkara entered into the search with great care and intelligence, and although they had never hunted for fossil bones before showed an enthusiastic reverence for a delicate object which was delightful to watch as expressed in the display of smiling rows of ivory white teeth at a word of encouragement. The labor question was solved and the problem now became one of extensive excavation, of handling and removing great quantities of sand, of uncovering and taking up the sometimes firm, sometimes extremely delicate and fragile bones, of keeping a very sharp lookout for small objects, and especially for the smaller animals of the period which have thus far not been discovered. Coarse river-deposited sands are evidently not favorable for the preservation of very small objects, but very careful methods of search were soon rewarded by the discovery of small jaws of the creodonts or primitive carnivora of the period, and even more interesting rodents, which had hitherto not been found. At the end of ten days the system of stripping and quarrying was thoroughly established and progressing as rapidly as the slower work of treating the bones with solutions of gum arabic and shellac could follow. Limb bones, teeth and jaws of *Arsinoïtherium, Palæomastodon, Saghatherium, Ancodus, Pterodon* began to appear in encouraging numbers and in fairly good condition.

The members of the excavating party were ever stimulated by the hope that the much-desired skull of one of these mammals might come to light. Skulls are, however, very rare. Of the primitive elephants only two fragmentary skulls of *Palæomastodon* and two of the more primitive *Mœritherium* have been found after many years' work. One of each was found by accident while surface prospecting. Two skulls of *Palæomastodon* are reported to have been found by a collector who did not understand how to preserve them. Of *Arsinoïtherium* six skulls have been secured; three of these, all very perfect, are in the Cairo Museum, one in the British, a fifth is in the Stuttgart Museum, a sixth, said to be the largest and finest, was destroyed in transit. Of these six skulls four were found in surface prospects and two in quarrying.

The region has been so thoroughly prospected since 1901 that the chances of easily

securing fine surface prospects are very remote. The bones weather out in pure white color, are very conspicuous and can be seen a long distance. In fact, the halcyon days of easy collecting have passed, just as they have passed in our western tertiaries. A party will only succeed through thorough, systematic and prolonged search and excavation. On these lines and with this expectation the work of the American Museum has been established by Professor Osborn on a two or three months' footing or as long as the weather is tolerably cool. A train of eight camels is constantly moving to and fro, keeping the camp supplied with water, a three to four days' round journey. Mr. Walter Granger, assisted by Mr. George Olsen, is left in charge. It is hoped that with the aid of fifteen selected workmen, not only a representative collection of these very important mammals may be secured, but considerable additions may be made to our knowledge, especially of the smaller mammals of the Upper Eocene period in Northern Africa.

H. F. O.

Cairo, February 25, 1907

SCIENTIFIC NOTES AND NEWS

M. Pierre Eugène Marcellin Berthelot, the eminent chemist, died in Paris on March 18, at the age of eighty years. M. Berthelot was permanent secretary of the Paris Academy of Sciences. He was a life member of the French senate and had been minister of public instruction and minister of foreign affairs. The Chamber of Deputies, after making an appropriation for a public funeral, adjourned in his memory.

Mr. C. G. Abbot, who had been for a number of years Secretary Langley's principal assistant in the Astrophysical Observatory of the Smithsonian Institution at Washington, and latterly its acting director, has been appointed director of the observatory, and Mr. F. E. Fowle, Jr., hitherto junior assistant, has been appointed aid.

Professor W. K. Brooks, of the Johns Hopkins University, will join Dr. A. G. Mayer, the director of the Tropical Marine Laboratory of the Carnegie Institution, at Nassau in April, for zoological research in the deep waters of the Bahamas.

The organizing secretary of the Section on Embryology of the Seventh International Zoological Congress is Professor E. G. Conklin, of the University of Pennsylvania. Pending his return from a short trip to the Bahama Islands, he desires to call the attention of workers in the fields of normal and experimental embryology to the opportunities which will be offered for the presentation of important papers in these subjects, and to request their cooperation in making the meetings of this section highly successful.

Dr. Francis Henry Smith, professor of natural philosophy in the University of Virginia since 1853, has retired from active service.

Professor Gætano Lanza, head of the department of mechanical engineering of the Massachusetts Institute of Technology, has received a decoration from the king of Italy, conferred by the Italian consul at Boston, Dr. Gustavo Tosti, at a banquet given in his honor.

The London Society of Dyes and Colors has founded in honor of Sir William Perkin a Perkin medal to be conferred for scientific and industrial work connected with the dyeing industries.

The centenary of the Imperial Operating Institute, a department of the University of Vienna, was celebrated on March 15. Many distinguished surgeons attended the evening proceedings, which took the form of a Lister festival, in honor of Lord Lister's eightieth birthday.

M. Henri Poincaré has been appointed a member of the council of the Observatory of Physical Astronomy at Meudon, in the room of the late M. Moissan.

The Technological Institute in Vienna has conferred an honorary doctorate of engineering science on Baron Auer von Welsbach.

The University of Glasgow will confer its doctorate of laws on Sir George Watt, author of the 'Dictionary of the Economic Products of India'; M. Emile Boutroux, professor of philosophy and director of the Fondation

Thiers, Paris; John Norman Collie, Ph.D., F.R.S., professor of organic chemistry, University College, London; Signor Ulisse Dini, professor of mathematics in the University of Pisa; Professor Adolf Harnack, director of the Royal Library, Berlin, and author of many works on ecclesiastical history; M. Henri Poincaré, professor of mathematics and astronomy at the Sorbonne; emeritus Professor of Physiology John Gray McKendrick, and Principal Donald Macalister, of the university, and recently lecturer in medicine at Cambridge University.

PROFESSOR F. W. PUTNAM, of Harvard University, has recently received word from Dr. W. C. Farabee, head of the Peabody Museum South American Ethnological Expedition, which started December 17, 1906, of its safe arrival at Arequipa, Peru, where the Harvard Observatory is situated. The expedition will make its headquarters at Arequipa, from which place the members will make excursions of several months' duration in order to study the manners and customs of the South American Indians of that region.

DR. OTTO LUMMER, professor of physics in the University of Breslau, who came to this country to give a course of lectures at Columbia University, gave an address before the Philosophical Society of Washington on March 21. The subject of the address was 'The Determination of the Temperature of the Sun, and Recent Solar Theories.' The meeting was held at the Bureau of Standards and was followed by a reception.

THE annual lecture of the Michigan chapter of the Society of the Sigma Xi was given on March 22, by Professor W. E. Castle, of Harvard University, his subject being 'The Experimental Study of Heredity.'

DR. WILLIAM R. BROOKS, director of the Smith Observatory and professor of astronomy at Hobart College, Geneva, N. Y., delivered an illustrated lecture at Clark University on March 15, his subject being 'Other Worlds than Ours.'

AT the meeting of the Botanical Seminar of the University of Nebraska, on March 22, Dr. Roscoe Pound delivered an address on the life and work of the late Dr. Otto Kuntze, whose death at San Remo, Italy, occurred on January 28, 1907. The address, which was of the nature of an 'appreciation,' will be published in an early number of SCIENCE. The second paper read was by Dr. Edith Clements, on 'Stability and Evolution,' and was based on her studies of particular species in the Rocky Mountains.

MISS CRUICKSHANK has presented to the University of Aberdeen a handsome window in the Library at Marischal College, in memory of her father, the late Dr. John Cruickshank, professor of mathematics from 1817 to 1860, and librarian from 1844 to 1860; and two portraits in oils—one of Sir Archibald Simpson, the architect of Marischal College; the other of James Ferguson, the astronomer.

PROFESSOR W. H. BAKHUIS-ROOZEBOOM, who carried forward to an important extent the work on physical chemistry inaugurated by Willard Gibbs, and who succeeded Professor van't Hoff at Amsterdam in 1896, died on February 8, at the age of fifty-three years.

M. MARCEL BERTRAND, professor of geology in the Paris School of Mines, died on February 25, at the age of sixty years.

DR. GUIDO KRAFFT, professor of agriculture in the Technical Institute at Vienna, died on February 22 at the age of fifty-two years.

MR. NOBLE HARTER, known to psychologists for an important piece of research work on the telegraphic language, carried on in conjunction with Dr. W. L. Bryan, died in South Pasadena, Cal., on February 23.

THE deaths are also announced of Dr. Mathias Marie Duval, professor of histology at the Paris Faculté de Médicine and at the Ecole d'Anthropologie; of Professor Y. Y. Tswetkoff, professor of mathematics at the Moscow Forestry School, and of Professor Karl Mayer-Cymar, the paleontologist of Zurich.

THERE will be a civil service examination on April 17–18 for the position of scientific assistant in the Department of Agriculture,

at salaries ranging from $600 to $2,000 per annum, depending upon experience and qualifications. As a result of this examination certification will be made to fill a vacancy in the position of scientific assistant qualified in seed testing, in the Bureau of Plant Industry, at $900 per annum.

There will be a civil service examination on April 24–25 to fill positions as assistant geologist and geologic aid in the Geological Survey, at salaries ranging from $1,000 to $1,600 a year. The department estimates that ten appointments will be made at an early date as a result of this examination, the salary depending upon qualifications and experience. In certain cases where only a portion of the time of the appointee can be given to the work of the department, the compensation will be upon a per diem basis for the service rendered. Appointments to the position of temporary field assistant will also be made from the resulting eligible list as far as possible. The compensation of such positions ranges from $60 to $100 per month, and the length of employment from three to seven months. At the same time there will be an examination for the position of geologist in the Philippine service at a salary of $1,800.

Funds have been donated by Mr. William C. Sproul, state senator, of Chester, Pa., for the purchase of one of the largest telescopes on the Atlantic Coast for Swarthmore College. The exact amount of the gift or the size of the telescope is not known, but the instrument will be quite as efficient as the government's telescope at Washington or the University of Virginia's telescope at Charlottesville, which are the two largest instruments in the east. The telescope will be in charge of Dr. John A. Miller, professor of mathematics and astronomy. Senator Sproul is a member of the board of managers and has been active in the advancement of the institution since his graduation in 1891.

There has been placed in the case in the paleontological museum of the University of Kansas a fine skeleton of the extinct *Bison occidentalis*. This unique specimen was collected by Mr. H. T. Martin in Give County, Kans., and mounted by him. It has an extreme length of 122 inches and a height of 79½ inches.

It is said that a compromise has been effected by which the city of Philadelphia will receive $1,000,000 from the estate of Dr. Thomas W. Evans for the establishment of a dental institute and museum.

The commissioners for the 1851 Exhibition have appropriated a site on their estate at South Kensington for the Institute of Medical Sciences. It is understood that the site will be reserved for one year, during which it is hoped that the additional sum of about £30,000 required to build and equip the institute may be obtained.

The fourth International Congress of Mathematicians will meet at Rome, from April 6 to April 11, 1908. The membership fee is twenty-five francs, and the general secretary on organization is Professor G. Castelnuovo.

The eighth meeting of the Association of Teachers of Mathematics of the Middle States and Maryland will be held at Teachers College, Columbia University, New York, on April 6, under the presidency of Professor Edwin S. Crawley, of the University of Pennsylvania.

The House of Commons on March 23, by 150 to 118 votes, rejected the bill proposing to introduce the metric system into Great Britain.

According to the daily papers, letters from Messrs. Ernest Leffingwell and Elmar Mikkelsen, containing the first news from the Anglo-American polar expedition since the expedition left Alaska, have been received at Portland, Ore., by Mr. H. A. Andree, assistant in the local weather bureau. The letters were dated November 21 and November 23 and were carried over the ice fields to Point Barrow, where they were delivered to the Canadian mounted police. Mr. Leffingwell states that the ship, the *Duchess of Bedford,* was frozen in solid ice, about 200 miles off Point Barrow and that the preparations were at that time almost completed for starting the expedition into the unknown country lying to the north.

IT is the purpose of the Geological Survey of Canada to distribute a number of surplus volumes of its publications. In so doing, it is proposed to allow all persons, libraries, societies, etc., now on the distribution list, the opportunity of completing their sets of these publications. The number of each publication in stock varies, and the volumes will be distributed in order of the receipt of the applications, until exhausted. Applications should be addressed to Mr. A. P. Low, director, Ottawa.

THE Biological Laboratory of the Brooklyn Institute of Arts and Sciences at Cold Spring Harbor, Long Island, will hold its eighteenth session, beginning on July 3, and continuing for six weeks. Courses are offered in field zoology by Dr. Chas. B. Davenport, Dr. H. E. Walter, of Brown University, and Dr. W. M. Wheeler, of the American Museum of Natural History; in bird study, by Mrs. Walter; in comparative anatomy, by Dr. H. S. Pratt, of Haverford College, and Mr. D. S. Hartline, of the Pennsylvania State Normal School; in invertebrate and general embryology, by Dr. A. L. Treadwell, of Vassar College, and Mr. H. E. Jordan, of Princeton University; in cryptogamic botany by Dr. D. S. Johnson, of Johns Hopkins University, and Mr. H. H. York, of the University of Texas; in plant ecology by Dr. E. N. Transeau, formerly professor of botany at Alma College and now of the Carnegie Institution of Washington, and Mr. W. S. Cooper, of Johns Hopkins University; in microscopic methods by Mrs. Davenport. Opportunity is afforded for original investigators who wish to work in private rooms. Persons who wish to make use of the laboratory should correspond with the director, Dr. C. B. Davenport, Cold Spring Harbor, N. Y.

THE Biological Survey of Michigan in charge of the state geologist has just issued a report covering the Terrestrial Pulminata of the state by Bryant Walker, copiously illustrated.

WE learn from *Nature* that on March 5 a deputation representing the Anthropological Institute, the British Science Guild and other scientific bodies, waited upon the Prime Minister to urge the establishment of a national anthropometric survey. Mr. R. C. Lehmann, M.P., who introduced the deputation, said that, in the first instance, the survey should have for its object the periodic measurement of children and young people in schools and factories. Besides this, a comprehensive survey of the general population of the whole country should be undertaken. The sum asked for is £4,000 or £5,000. The need for such a survey was described by Dr. D. J. Cunningham, Mr. J. Gray, Dr. Gow, Sir Lauder Brunton and Dr. A. C. Haddon. In his reply to the deputation, Sir Henry Campbell-Bannerman confessed that he has been much impressed by the arguments adduced as to the great lack that there is in this country of knowledge of the quality of the population. It is obviously desirable to have a record of the kind proposed in order to be able to study the changes in the condition of the people at large as a guide to action in administration and in legislation regarding it. Any test applied to the condition of the inhabitants of any district is a test of their surroundings, of the mode in which they live, and the circumstances which affect their health and utility, and therefore this can not be an unimportant thing. It is very desirable to avoid any impression that a sort of experiment is to be practised upon the poor children in the common schools. Whatever is done to the poor ought to be done also to the rich, and the application of the system ought to be universal. In fact, it will cease to have its proper value if it is confined to the poor schools, which are a little more at the disposal of the government and the authorities than the great schools, such as Westminster and others. Results are wanted referring to the whole population, so that comparison may be made between different districts and different occupations. The sum mentioned for the survey is a modest amount, but a great many modest sums make up a large sum. But the mere question of cost is not likely to stand in

the way of a great scheme of this sort if the government is satisfied on full consideration—which shall be given to it—that the time is ripe for this new enterprise.

The Royal Academy of Sciences of Turin, in accordance with the will of its former associate, the late Senator Thomas Vallauri, will award a prize to the scientific investigator, of Italian or any other nationality, who between January 1, 1907, and December 31, 1910, shall have published the most important work in the domain of physical science, taking that term in its largest sense. The prize will be of the value of $5,500.

UNIVERSITY AND EDUCATIONAL NEWS

By the will of Francis P. Furnald, of New York City, Columbia University will receive on the death of his widow $300,000 for a dormitory, to be called Furnald Hall.

By the will of the late Captain Thomas P. Salter, of Portsmouth, New Hampshire, Dartmouth College will, on the death of his sister, receive the residue of his estate, estimated at about $250,000.

By the will of the late Mrs. James W. Queen $10,000 is bequeathed to Princeton University to found two scholarships in memory of the late James W. Queen.

By the will of the late General Samuel E. Merwin, of New Haven, $5,000 has been bequeathed to Yale University for the uses of the medical school.

The removal of the Connecticut Agricultural College at Storrs to a position nearer the center of population is being considered.

The Massachusetts Agricultural College will hold a Teachers' Summer School in Agriculture with Professor F. A. Waugh as dean.

The New York *Evening Post* states: In the Museum of Natural History of Vassar College much work is being done in rearranging and remarking the collections. A special collection illustrating all species of birds found in the southeastern part of New York State has been arranged in the interest of the members of the college who wish to study the local birds.

There is a movement to establish a second Danish University at Aarhuus, the capital of Jutland.

The council of the University of Manchester have decided to institute two new lectureships—one in economic zoology and one in economic botany.

Three hundred teachers from Toronto and a hundred from Brantford, London, Hamilton and other points will visit New York, Washington, Philadelphia and Baltimore during Easter week.

At the University of Virginia appointments have been made as follows: Dr. Stephen H. Watts, of Johns Hopkins University, professor of general surgery and director of the University Hospital; Dr. Thomas L. Watson, of the Virginia Polytechnic Institute, professor of economic geology; Dr. R. M. Bird, of the University of Missouri, collegiate professor of chemistry, and Dr. Arthur E. Austin, of Boston, adjunct professor of physiological chemistry.

Professor A. M. Soule, dean and director of the Virginia Polytechnic Institute at Blacksburg, has accepted a similar position in the Agricultural College of Georgia.

Mr. Clarence G. Derick, of the Massachusetts Institute of Technology, has been appointed laboratory and research assistant to Professor Noyes, for the coming year, at the University of Illinois.

The Alice Freeman Palmer fellowship at Wellesley College, which is of the value of $1,000, has been awarded to Miss Helen B. Cook, who will study psychology in Germany.

Mr. A. P. Parsons, formerly of the University of Minnesota, has been appointed lecturer in mineralogy and petrography in the University of Toronto.

Dr. Hermann Klaatsch, who is at present in Australia, has been appointed associate professor of ethnology in the University of Breslau.